DYNAMIC RESPONSES OF MINI-TLP (SEASTAR)

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by

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CERTIFICATION OF APPROVAL

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Approved by,

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements and that original work contained herein have not been undertaken or done by unspecified sources or persons.

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ABANG MOHAMAD ZAYD BIN ABANG OTHMAN

ABSTRACT

The focus of this research is on the Mini-Tension Leg Platform (mini-TLP). It is one of the available offshore floating structures that are available in the industry. To make sure that the construction of a mini-TLP is profitable, the optimum design need to be designed and there is a need to study more on the performance of this particular structure.. Similar to other offshore structures, mini-TLP is also exposed to the intense action of wind, current and wave in the sea. Hence, the structures need to be assessed in numerous aspects in order to optimize the cost and the performance of the platforms. Several analyses have been done in order to achieve the goal to come out with a structural dynamic response. Surge, Heave and Pitch Analysis were done to study the response of the structure due to random wave and current. Morison Equation is used in conjunction with Linear Airy Wave Theory. Wave spectrum is then applied to present an appropriate density distribution of the sea wave. From all the properties, Random Amplitude Operator (RAO) is then computed to determine the behavior of the structure when operating at sea. This particular research is then followed by a laboratory testing where a structural platform model was constructed and tested in the wave tank. Results of the laboratory prove the theories in term of the behavior of the structure. The research developed a manual calculation for the responses of a mini-TLP to random wave loading as well as detailed literature survey about this mini-TLP structure.

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LIST OF ABBREVIATIONS

E & P	Exploration and Production
Mini-TLP	Mini-Tension Leg Platform
P-M Spectrum	Pierson-Moskowitz Spectrum
PCSB	PETRONAS Carigali Sdn. Bhd.
RAO	Random Amplitude Operator
SI	International Standard Unit
TLP	Tension Leg Platform
USA	United States of America
UTP	Universiti Teknologi PETRONAS

CHAPTER 1
INTRODUCTION

1.1 Background of Study

An offshore structure can be defined as one which has no fixed access to dry land and it must remain in position in all weather conditions. The structure may experience small movement to provide stable environment for production activities. From several researches, it can be proven that a fixed structure such as jacket platform will experience greater forces as compared to the compliant structure. (Minoo H. Patel and Joel A. Witz, 1991)

Rapid development in the offshore industry has started over sixty years ago when the first fixed offshore platform was installed in 6.1m (20ft) water depth located in the Gulf of Mexico in 1947 (Chakrabati, 2005). Since that, the total number of offshore platforms of various types have exceeded 10,000 units. Recently, more than 9,000 fixed platforms have been installed in water depth up to 400m (Bullwinckle Jacket in Gulf of Mexico) and have reached installation weight of more than 650,000 metric tons (Troll A GBS in the North Sea) (Lokstad & Ahmad, 2005).

Nowadays, the development of minimal offshore oil fields in a hostile environment is currently being aggressively pursued to overcome the increasing demand of oil and natural gas. New concepts of platform construction and technologies of exploration, drilling and production are needed for the development of such fields. Among the concepts present in the oil and gas industry, Tension Leg Platform (TLP) and spar platforms are the most eye-catching. (Minerals Management Service, 2004)

A TLP is a floating structure, vertically moored to the seabed by a system of pre-tensioned tethers held in tension by the buoyancy of the hull. Many investigations have been carried out to study the behavior and the dynamic response of these platforms. The research is needed in order to achieve the optimum design which is related to the cost and performance of the platform. (Chakrabati, S.K., 2005)

One of the relatively low cost oil platforms is floating Mini-Tension Leg Platform (mini-TLP). It is used mostly for production of smaller deepwater reserves which would be uneconomic to produce a conventional deepwater production system. Mini-TLP consists of sea surface piercing cylinder supporting the deck and accessories with the excess buoyancy offered by fully submerged cylindrical hulls well below the surface. Vertical tension legs are attached to these buoyancy chambers. This mini-TLP has a low water plane area and thus it has less environmental loads and good response characteristics. However, the intricacy of the structural system was similar to that of conventional TLP. (Minerals Management Services, 2004)

Wind, currents and waves play a vital role in influencing the design of mini-TLP where all these three factors will make the design to the maximum offset. A parametric study has been be conducted study the dynamic response of this mini-TLP. (Bassam A. Younis[a,*] and Vlado P. Przulj[b], 2005).

1.2 Problem Statement

A typical compliant offshore platform is exposed to a combination of environmental loads which comprise wind, waves and currents. Two non-linear aspects have to be considered when designing a mini-TLP; amount of offset (minimum value of horizontal response) and limit (minimum or maximum) of tendon tension forces. (Chakrabati, S.K., 2005)

Although it is difficult to determine the exact portion of those three effects, it is generally agreed by research that no less than 60% of the total offset is due to the actions of currents alone to the members. In addition, the floatation of the structures must also be taken care of during the design stage. (Bassam A. Younis[a,*]and Vlado P. Przulj[b], 2005)

Due to the issues that a mini-TLP structure movement is affected by the action of wave and current that are unpredictable in the offshore, a study to determine the behavior of the structure needs to be done. The responses of the structure on the x-axis, y-axis and z-axis have to be examined. Studies on these parameters will ensure the effectiveness of the design. In economical point of view, a study on the behavior of this structure is very important to come up with an optimum design. This research has determined and studied the dynamic response of mini-TLP to all environmental factors that may have impacts to the structures to ensure that a design of mini-TLP can meet the objective to have an optimum performance.

1.3 Objective of Study

Three main objectives are as stated below:

a) Understand the concepts of a mini-TLP including the characteristics and the dynamic responses of the structure.

b) To conduct the dynamic analysis in order to observe the responses of mini-TLP due to effect of wave and current.

c) To compare the dynamic analysis with the laboratory simulation accordingly to the UTP wave tank capacity.

1.4 Scope of Study

This project will cover on the dynamic responses of a mini-TLP. The design parameters will be adopted from some of the design that are currently in the industry. However, some modification will be made in order to fit with the study requirement.

Some other key points that will be included in the scope of study are as follows:

a) To come out with detailed literature survey about the dynamic responses of mini-TLP.

b) To complete a dynamic analysis of mini-TLP with respect to surge, heave and pitch due to a random wave and current in the frequency domain.

c) To prepare an experimental model of mini-TLP suitable for UTP wave tank and compare the dynamic analysis with the laboratory simulation.

Some of the assumptions made for the research are as below:

a) This research will concentrate on the study in the deepwater area.

b) Some modification will be made on the dimensional and environmental data based on the actual project for mini-TLP.

CHAPTER 2
LITERATURE REVIEW

Tension Leg Platform (TLP) is a floating structure platform of relatively low cost which is developed for production of smaller deepwater reserves where it will be uneconomical to build a conventional fix platform. It can also be used as a utility, satellite, or early production platform for larger deepwater discoveries. (Chakrabati, S.K., 2005). The world's first TLP was installed in August 1985 in the Hutton Field of the North Sea by Conoco. Typical picture of a conventional TLP is shown in Figure 1.0. (Chakrabati, S.K., 2001)

Figure 2.1: Tension Leg Platform

It consists of a floating body, pontoons and a top working platform. The structures are anchored on the seabed by tendons. Hull provides buoyancy to support both weight of the platform as well as to provide tension to the tendon. (Chakrabati, S.K., 2001)

Nowadays, oil and gas exploration in water depth in the range of 700 m-1500 m is considered as deepwater. More than 1500 m depth will be considered as ultra deep water. At present, there are more than 15 rigs in the Gulf of Mexico drilling in the ultra deep water depth. According to the US Department of the Interior Service Deepwater Gulf of Mexico 2007 Report, there are over 4200 active leases in deepwater area with more than 15% of them which is 650 of them is in the water depth more than 2200 m. (Minerals Management Services, 2004)

The concept of a mini TLP called 'Sea Star' was proposed by Kibbee et al. (1996). This mini TLP is small in size with a single surface-piercing column. The column has a small water plane area and hence less surface loads and good motion characteristics. The submerged hull spreads into three structural members at the bottom of column in a triangular fashion that are used to support and separate taut steel mooring lines called tether or tendon. The hull provides sufficient buoyancy to support the decks, facilities and risers. The excess buoyancy induces tension in tendon. (Kang, D. H., 2005)

Several types of TLP were developed recently to suit the environment in the Gulf of Mexico. Most of the TLP which were built in the late 1990s is using square 4-column units. However there are also other types of TLP have been used which are 4 single-column designs or also known as Mini-Tension Leg Platform (mini-TLP) or Sea Star and 2 multi-column designs (Moses). (Chakrabati, S.K., 2005)

Looking back at the history of mini-TLP, a downsized four column mini-TLP for 1000 m water depth was proposed by Hudson and Vasseur (1996). A generic application mini-TLP then was proposed by Logan and Naylor (1996). Muren et al. (1996) developed a three column mini-TLP for water depth of 800 m which can be easily extended to 1500 m under shorter development schedule with significant cost reduction. (S.K Bhattacharyya *, S. Sreekumar, V.G. Idichandy, 2002)

Mini-TLP or Sea Star is also well known as the most economical structure for dry-tree production from ultra deep water fields. The world's first mini-TLP was installed in the Gulf of Mexico in 1998. This mini-TLP commences water-column oscillators to the hull. Figure 2.1 shows one of the typical mini-TLP existing in the industry. (Chakrabati, S.K., 2005)

Figure 2.2: Mini-Tension Leg Platform

These wholly inactive devices effectively eliminate wave-induced resonant motions and thus reduce the tension and stresses in the tubular tendons. Since tendon walls can now be produced thinner, tendon cost is significantly lowered and is no longer a limiting factor in deeper water technology. (Development Options with SeaStar TLPs, 2008)

The mono column hull with three radial pontoons of the mini-TLP is one is one of the most advanced buoyant shapes ever designed. It is designed to optimize the delivery of the maximum payload capacity for a hull with certain weight. Theoretically, a mini-TLP can sustain up to 1.8 times its own weight. A spar hull is supporting only 0.6 times its weight. The strength ratio of these two structures is about 1/3. This indicates that a mini-TLP is more reliable and economical structure to be used in the deep water area. (Development Options with SeaStar TLPs, 2008)

The concepts of mini-TLP or a Sea Star which has a simple geometry, with a vertical cylindrical hull connected to three radials tapered rectangular pontoons is shown in Figure 2.2. The horizontal pontoons of a mini-TLP on the other hand can help to improve the "lightly damped heave motion" of cylindrical hull column, which is potentially problematic for classical spars. The well separated tendons at the end of the pontoons improve the yaw and pitch motions. These motions are most likely undesirable features of spars in many circumstances. (S.K Bhattacharyya *, S. Sreekumar, V.G. Idichandy, 2002)

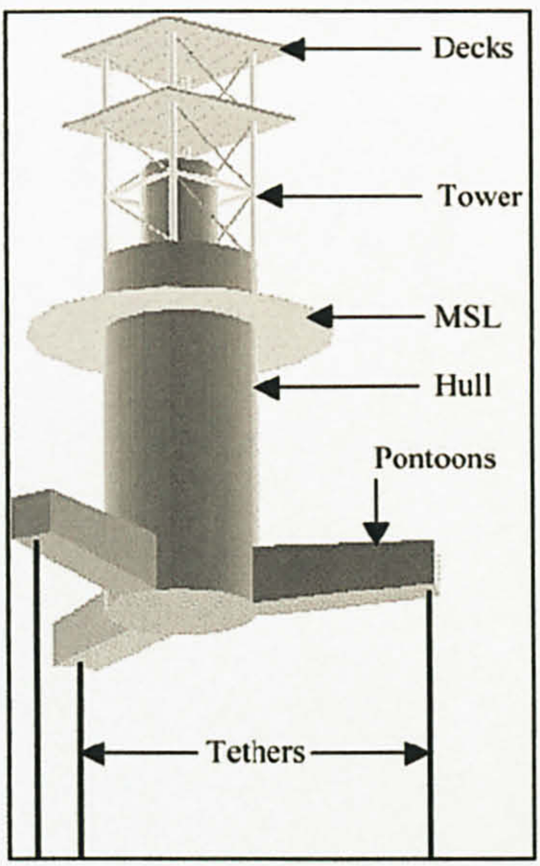

Figure 2.3: Sea Star Concepts

The study of the overall dynamic response of the structures of mini-TLP will begin by performing a series of numerical computation.

One of the most important theories used in this research is the small amplitude linear wave theory known as Linear Airy Wave Theory. It is derived based on the assumption that wave height is small compared to the wave length or water depth. The assumption is accurate within a certain range and most likely will not be accurate in storm condition where the waves are steeper. (Chakrabati, S.K., 2001)

Stream function theory which is nonlinear solution uses the summations of sine and cosine wave forms to develop a solution to the original differential equation. The stream function theory determines the coefficient to obtain a least-squares fit to the posed free-surface boundary conditions so that a better solution is obtained. (Ram Powell, Gulf of Mexico, USA, 2009)

Morison equation will also be used for the purpose of wave force that is acting on a vertical pile which extends from the bottom through the free surface. This equation was developed by Morison, O'Brien, Johnson and Shaaf (1950). The assumption made for this equation is the total force acting on the member is the sum of inertia forces and the drag forces which are linearly added together. The equation can only be used when the drag force is significant where the wave height is relatively small compared to the water wave length or water depth. (Chakrabati, S.K., 2001)

This equation is working on the principle which a water particle moving in a wave is carrying a momentum with it. The particles will keep on accelerate and decelerate while moving around the circular cylinder. (Chakrabati, S.K., 2001)

In this study, P-M spectrum model will be used to study the energy from wind that is acting on the structures. Pierson and Moskowitz (1964) has proposed a new formula for an energy spectrum distribution of a wind generated sea state based on more accurate data which is commonly known as P-M model. It has been widely used since this model one of the most representative for water. (Chakrabati, S.K., 2001)

P-M spectral model shows a fully-developed sea which is determined by the wind speed. The fetch and the duration of the wind is to be assumed as infinite where the wind has to blow over a large area at a nearly constant speed for many hours prior to the time when the wave record is obtained without any significant amount of wind direction changes. This model is also useful in representing a severe storm wave. (Chakrabati, S.K., 2001)

Surge, heave and pitch are also being assessed in this study. Surge is the motion of the structure forward and backward due to the action of the wave and the current at the x-axis. Meanwhile heave is the movement of the structure up and down at the y-axis whereas pitch is the rotation of the structure at the x-axis.

From that surge, heave and pitch properties, Random Amplitude Operator (RAO) will be computed. RAO is used to determine the behaviour of a structure when operating at sea and effect that a sea state will have upon the motion of a structure through the water. RAO is a transfer function that transfers the wave properties into the response amplitude of a structure.

CHAPTER 3
METHODOLOGY

3.1 Structural Model

The platform is modelled as a rigid body with three degrees-of-freedom (i.e. surge, heave and pitch) and its centre of gravity, connected to sea floor by tethers, which are attached to the seabed. The tethers keep the platform stable at the location. The centre of gravity the platform is always above the centre of buoyancy to provide inherently stable design for the platform. The dimension of the platform is given in Table 3.1.

Table 3.1: Dimensional and Structural Data of Case Study

Properties	Value
Main Column Diameter	25 m
Draft	30 m
Pontoons	3
Effective Radius	55 m
Pontoon Heights	12 m (column), 8 m (tip)
Payload Support	7500 t
Hull weight	5500 t
Primary Hull Structure	4500 t
Displacement	23500 t
Freeboard	20 m
Operating Weight	6000 t
Tendons	6 x 0.8 m

All the parameters are based on the real project which is from Matterhorn Field, Gulf of Mexico, USA. However, modification and adjustment will be made accordingly to the need and limitation of the research. This data will also be used as the base if the structure modelling is needed. The model will be design scaled from the real data obtained.

The sketch of the mini-TLP is shown below:

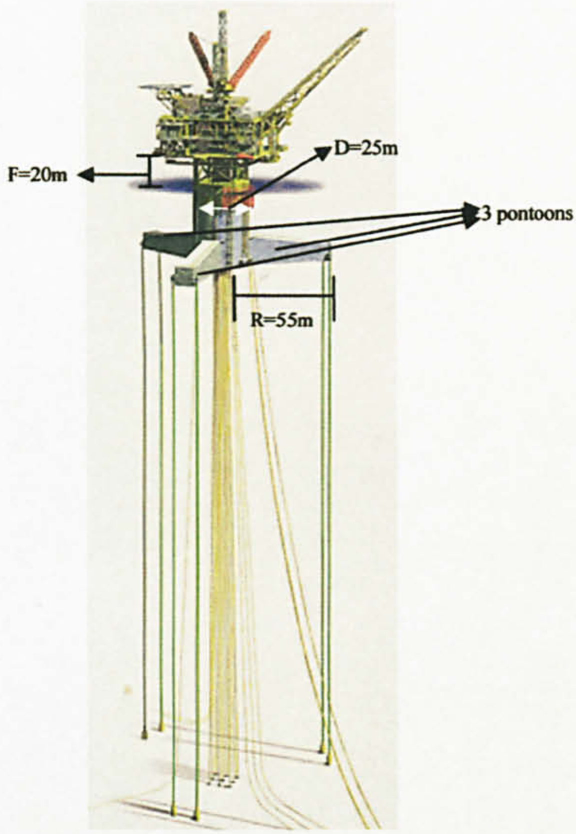

Figure 3.1: Sketch of Mini-TLP

Where;

D = Main column diameter

R = Effective radius

F = Freeboard

The Metocean data that will be used in this study is the data from Baram Delta site located at Sarawak offshore. This site is 75 m deep. However, modification has been made to the water depth that is used in the research. Due to the constraint to the mini-TLP structure where it is economically suitable for deep water exploration, the water depth for this research is taken as 500m.

Table 3.2: Baram Delta Metocean Data

Parameters	Units	Operating Criteria
WIND		
1-min mean	m/s	25
3-sec Gust	m/s	28
WAVE		
Hs	m	3.6
Tz	sec	6.6
Tp	sec	9.3
Hmax	m	6.4
Tass	sec	8.6
OCEAN CURRENT		
At Surface	m/s	1.4
At Mid-depth 0.5*D	m/s	1.3
At near seabed 0.01*D	m/s	0.7

Main parameters used are the significant height, H_s, maximum height, H_{max}, and associate time, T_s. For the effect of current the ratio given is used to calculate the velocity of current at the depth of 0.01D, 0.5D as well as at the surface of the sea. All those forces are used to compute the effect of the forces on the hull and the pontoon.

3.2 Wave Force Calculation

The wave force acting on an offshore structure is the most important environmental loadings. The wave forces are developed because of the motion of water particles hitting the structure with velocities and accelerations. The approach used to predict the wave forces is based on unidirectional wave design to obtain the highest expected wave forces. The calculation is based on the Morison's equation applied in conjunction with Linear Airy Wave Theory. (Chakrabati, S.K., 2001). Morison's equation expresses the wave forces as the sum of an inertia forces proportional to the particle acceleration and a non-linear drag force proportional to the square of the particle velocity:

Table 3.3: Morison Equation

Inertia Force	Drag Force
$df_I = C_M \rho \frac{\pi}{4} D^2 \frac{\delta u}{\delta t} ds$	$df_D = 0.5 C_D \rho D \lvert u \rvert u ds$
Total Force	
$F_t = df_I + df_D$	

Where;

C_M = Inertia coefficient

C_D = Drag coefficient

ρ = Sea water density, $\frac{kg}{m^3}$

D = Hull diameter, m

$\frac{\delta u}{\delta t}$ = Sea water particle acceleration, $\frac{m}{s^2}$

u = Sea water particle velocity, $\frac{m}{s}$

δs = Length of structure's segment, m

By using Linear Airy Wave Theory, with a wave height and wave period chosen according to the location of the structure, the corresponding horizontal and vertical components of wave particle velocity and acceleration were determined. (Chakrabati, S.K., 2001) The kinematics of the wave water was determined by the following equations;

Table 3.4: Linear Airy wave Theory

	Horizontal	**Vertical**
Velocity	$u = \frac{\pi H}{T}\frac{\cosh ks}{\sinh kd}\cos\Theta$	$v = \frac{\pi H}{T}\frac{\sinh ks}{\sinh kd}\sin\Theta$
Acceleration	$\frac{\delta u}{\delta t} = \frac{2\pi^2 H}{T^2}\frac{\cosh ks}{\sinh kd}\sin\Theta$	$\frac{\delta v}{\delta t} = \frac{2\pi^2 H}{T^2}\frac{\sinh ks}{\sinh kd}\cos\Theta$

Where,

H = Wave height, m

T = Wave period, s

k = Number of wave, $\frac{1}{m}$

s = Distance from seabed to analyzed position, m

d = Water depth, m

Θ = Crest angle

The computation of wave forces on the platform is divided into four sections which are the Hull, Pontoon A, Pontoon B and Pontoon C. The wave is assumed to attack the structure in the X-direction. The platform is considered in a vertical plane (i.e. no inclination in Y-axis).

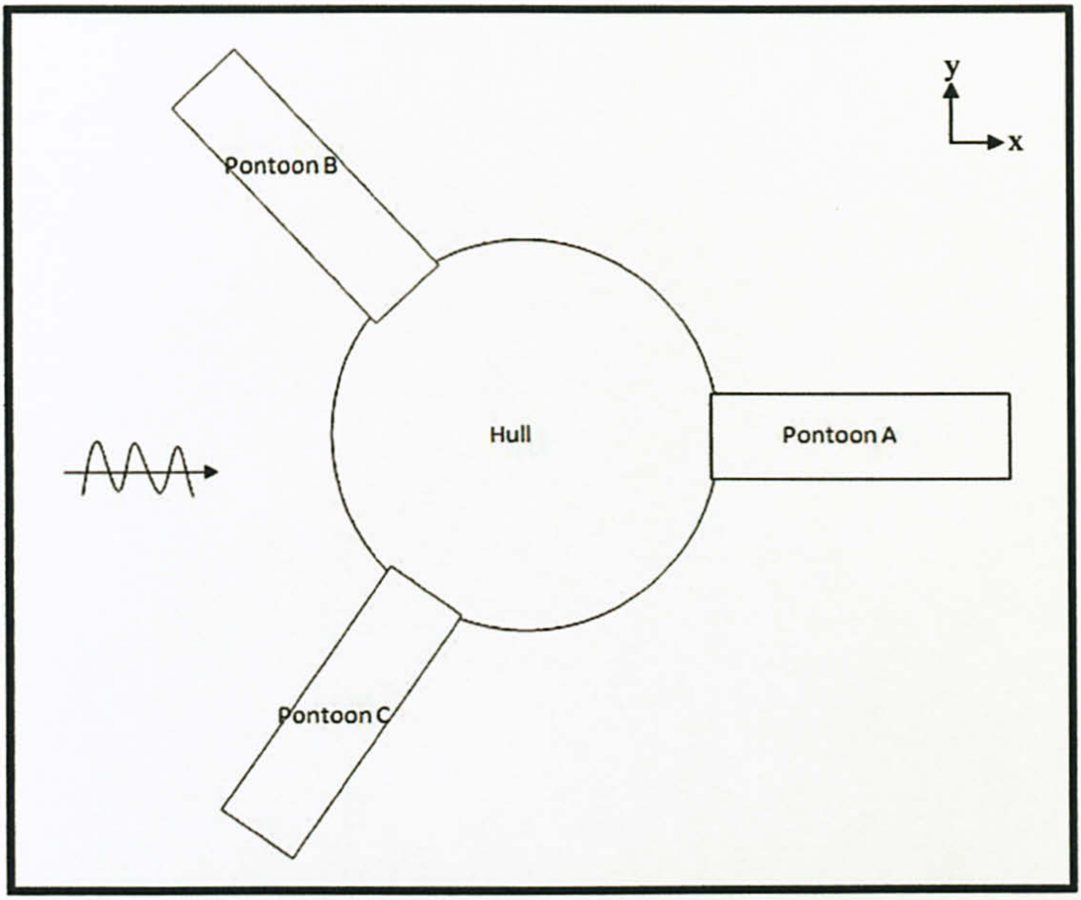

Figure 3.2: Force on the Mini-TLP

Wave forces acting on the hull was analyzed for every 1.0m interval and the force was assumed to act at the centre of each segments determined. All forces acting (on the segments determined) on the hull is then sum up to compute the value for total forces acting on the entire structure.

Method used to analyze the forces experienced by the pontoon; Pontoon A, Pontoon B and Pontoon C is simplified. Morison Equation is used in conjunction with Linear Airy Wave Theory. The procedure is almost the same as the procedure to calculate those forces acting on the hull. Forces on the section were assumed to act at the centre of the truss members.

3.3 Wave Spectrum

Frequency domain analysis is done first by choosing a suitable wave spectrum model to present an appropriate density distribution of sea wave at the site under consideration. Random waves in the sea are a result from the linear superposition of an infinite number of regular waves with various frequencies. The best means to describe a random sea state and its energy content (distribution over a frequency range) is by using the wave energy density spectrum S(f). (Chakrabati, S.K., 2001) The energy density spectrum, Pierson-Moskowitz (P-M) spectrum model is used for the frequency domain analysis. Expression in terms of the cyclic frequency ($f = \frac{\omega}{2\pi}$) for the P-M spectrum will be applied:

$$S(f) = \frac{\alpha g^2}{(2\pi)^4} f^{-5} \exp\left[-1.25\left(\frac{f}{f_0}\right)^{-4}\right]$$

Where;

α = 0.0081

g = $9.81\frac{m}{s^2}$

π = 3.141593

f = Waves frequency, Hz

f_0 = Waves peak frequency, H

In order to compute the forces acting on the structures and to determine the responses of the structure, the height of wave need to be obtained from a particular frequency form the energy density spectrum.

Formula used to determine the wave height is:

$$H(f_I) = 2\sqrt{2S(f_I)\Delta f}$$

Where;

$S(f_I)$ = Wave spectrum, m^2s

f = Wave frequency, Hz

Then, the wave profile can be calculated by using the formula below:

$$\eta(x,t) = \sum\left(\frac{H(n)}{2}\right)\cos[k(n)x - 2\pi f(n)t + \varepsilon(n)]$$

Where;

k = Number of wave, $\frac{1}{m}$

x = Horizontal coordinate, m

t = Time, s

f = Wave frequency, Hz

$\varepsilon(n)$ = $2\pi R_N$ (R_N is random number ranged from 0 to 1)

3.4 Random-Amplitude Operator (RAO)

The responses of the structure towards the motions of surge, heave and pitch are calculated by multiplication of the wave energy spectrum with the square of RAO function to evaluate the response spectrum value at particular frequency. (Chakrabati, S.K., 2001)

RAO formula can be defined as;

$$RAO = \frac{\frac{F}{\left(\frac{H}{2}\right)}}{\sqrt[2]{(K - m\omega^2)^2 + (C\omega)^2}}$$

Where;

F = Force acting on the structure

H = Maximum wave height, H_{max}

K = Surge/Heave stiffness

m = Total mass of structure

C = Damping coefficient

ω = Surge/Heave natural frequency

3.5 Experimental Model

The model is designed accordingly to the availability of UTP wave tank. Maximum water depth that can be used is 1.1m with 0.3m wave height. The sketch of the model is shown below;

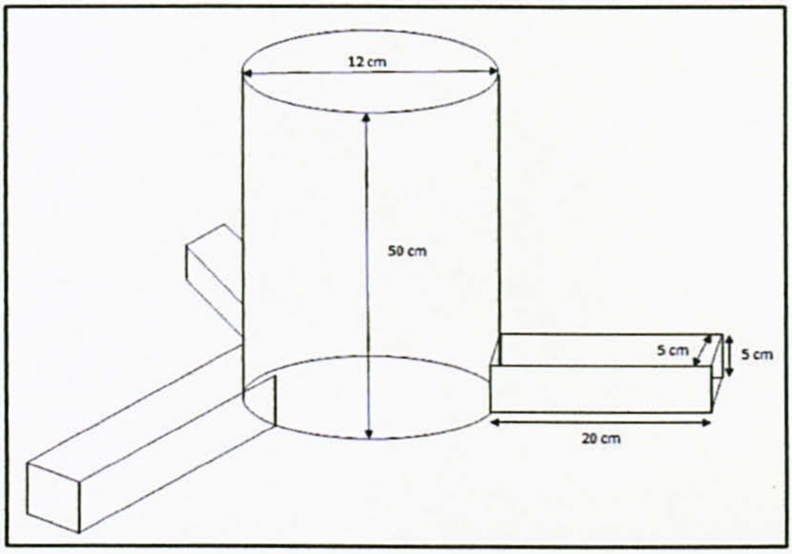

Figure 3.3: Platform Model Sketch

The model is fabricated within by using Perspex and the structure is made water proof to ensure the model can be floated in the tank. The structure is attached to the tank's base by using steel chain. Draft for the structure is determined by adjusting the length of the steel chain.

The tank is filled up to 0.8 m water depth and the wave height set for the experiment is 0.057 m. Stability of the structure model is first must be ensured to be in a balance condition. The attachment of the structure with the steel chain and the connection of the chain to the base of the tank must be strong enough to avoid any unplanned incident. Figure on the next page shows the setup of the structure in the wave tank;

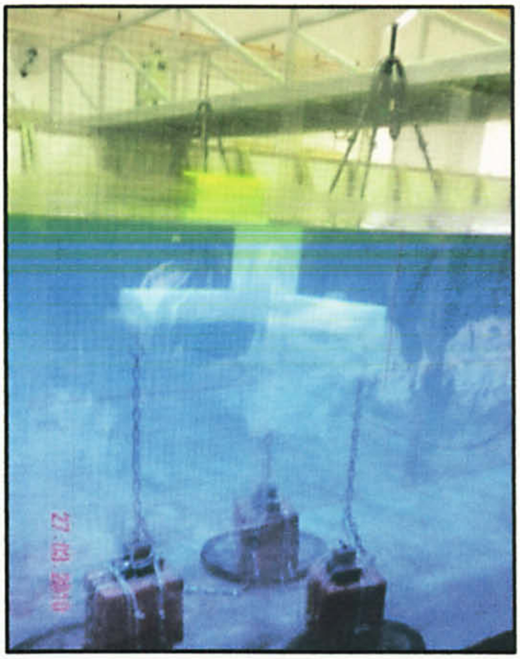

Figure 3.4: Model Setup in the Wave Tank

Experiment was done by simulating a P-M Wave in the tank. It is to model the random wave which is almost similar to the actual condition in the sea. The wave is the general condition of the free surface on a large body of water with respect to wind waves and swells at a certain location and moment. It is characterized by statistics, including the wave height, period, and power spectrum. The wave generated varies with time, as the wind conditions or swells conditions change. The properties used in the test are shown below;

Table 3.5: Laboratory Testing Data

Wave Period	1.2 s
Wave Height	0.057 m
Frequency	0.833 Hz
Water Depth	0.8 m

3.6 Project Flow

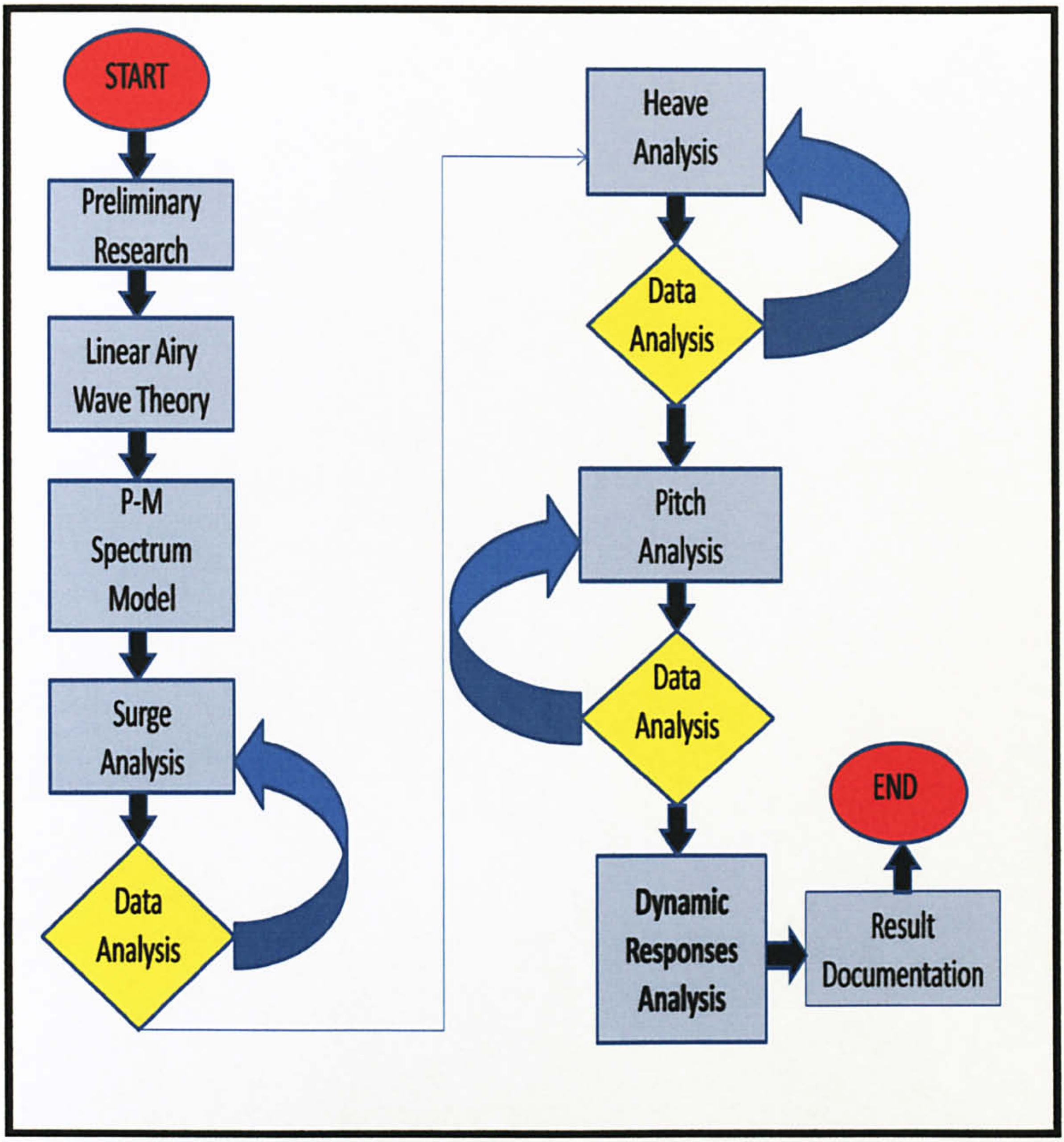

Figure 3.5: Project Flow

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Wave Forces

Wave forces calculated using Morison's equation at different sections of the platform is summarized in APPENDIX B. According to the wave force distribution, most of the forces are taken hard by the hull and all the three pontoons experienced insignificant wave force.

Wave forces acting on the hull is found to be attacking on the X-direction and Y-direction. Forces acting on the Y-direction are due to the buoyancy of the hull itself. There are no forces acting on the Z-direction since the initial forces is assumed to be acting on the X-direction.

For the pontoons, there are forces acting at all directions (i.e. X-direction, Y-direction, and Z-direction). There are no F_z for pontoon A since the forces are assumed to be parallel with it. However there are forces with same magnitude acting on pontoon B and pontoon C. The direction of the forces will make them to cancel each other and leave the total forces acting on the Z-direction to be zero.

Values calculated are approximately estimated from the real value from the Matterhorn Field, Gulf of Mexico, USA. There might be slight differences in the final value since there are a lot of assumptions taken into account. At the first place, assumptions made are on the total weight of the structure and the axial stiffness for each tether. The actual weight of this platform could not be exact since there might be some differences with the planned structure and the actual structure and since the axial stiffness for each tether is not provided, the value for the stiffness is assumed to be typical. Surge and heave properties calculation will then affected by the stiffness value and the total weight of the structure. To calculate the surge, heave and pitch added masses, the value from the assumed data will be used.

The Response-Amplitude Operators (RAO) will be affected due to the random wave. As the waves differ, the likely behavior the platform structure when operating at sea changed as well.

4.2 Wave Spectrum

The wave energy spectrum is determined and the significant height is obtained from a wave record. The P-M spectrum is drawn ranging from the frequencies of 0.005 Hz to 0.4 Hz. A record of significant height H_s=3.6m is used. Corresponding wave height from each frequency in the range was obtained and shown in Figure 4.1.

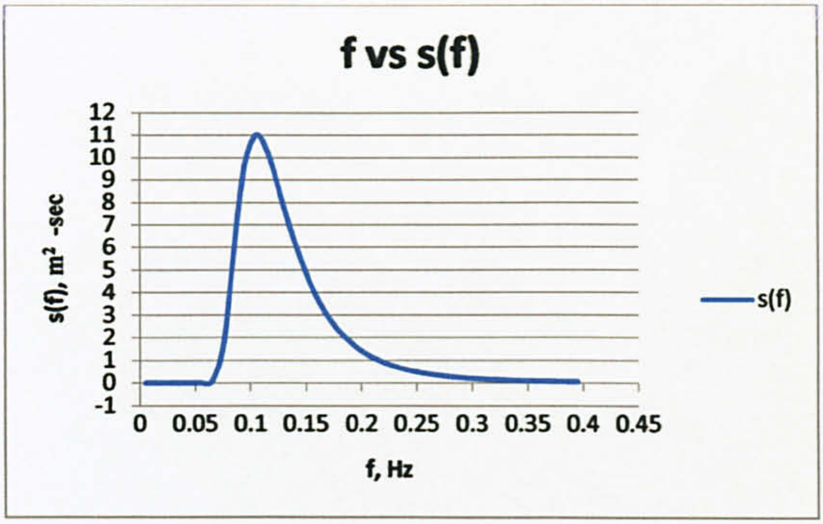

Figure 4.1: P-M Spectrum

The corresponding wave height is calculated from each frequency in the range obtained. From calculated wave height, the time history of the wave profile (t=0s to t=100s) in front of the mini-TLP at x=0m was computed ad a random phase in the range of (0,2π) was assigned to a random number generator R_N to retain randomness of the history. The wave profile is shown in Figure 4.2. Refer APPENDIX C for the detail calculation of wave spectrum.

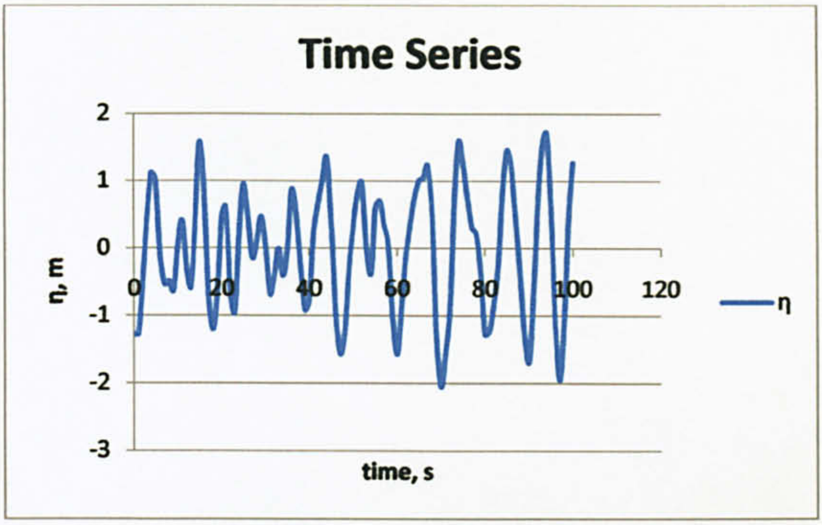

Figure 4.2: Wave Profile

4.3 Motion-Responses Spectrum

Three types of motions (i.e. surge, heave and pitch) are calculated. The responses are calculated based on the structure damping ratio of 5%. Basic calculation for the platform buoyancy calculation is shown in APPENDIX D. The calculation for surge constant is attached in APPENDIX E. Meanwhile for heave and properties, the computation is attached in APPENDIX F and APPENDIX G respectively. The calculation for properties to be used in the RAO calculation is attached in APPENDIX H. Spreadsheet used for the RAO computation is attached as well in the same section

H_s=3.6m is used in the calculation. Figure 4.3, 4.4 and 4.5 illustrates the response spectrums for surge, heave and pitch. The responses have a maximum peak value close to the wave spectrum peak.

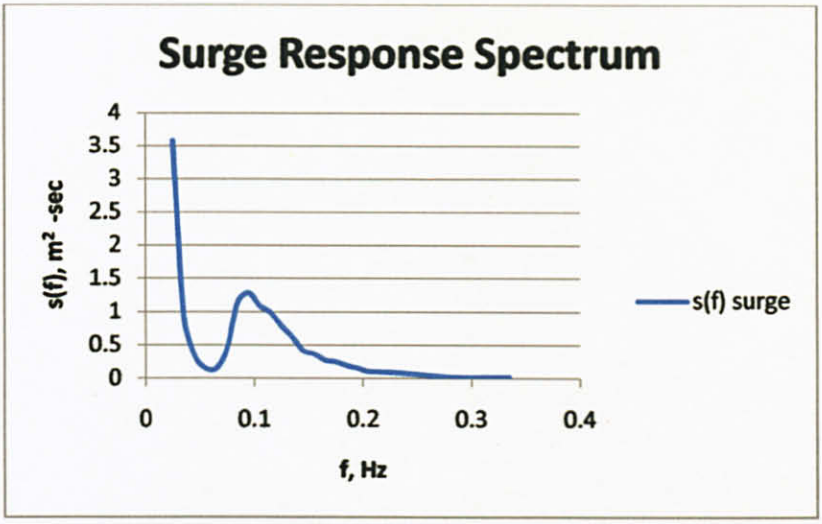

Figure 4.3: Surge Response Spectrum

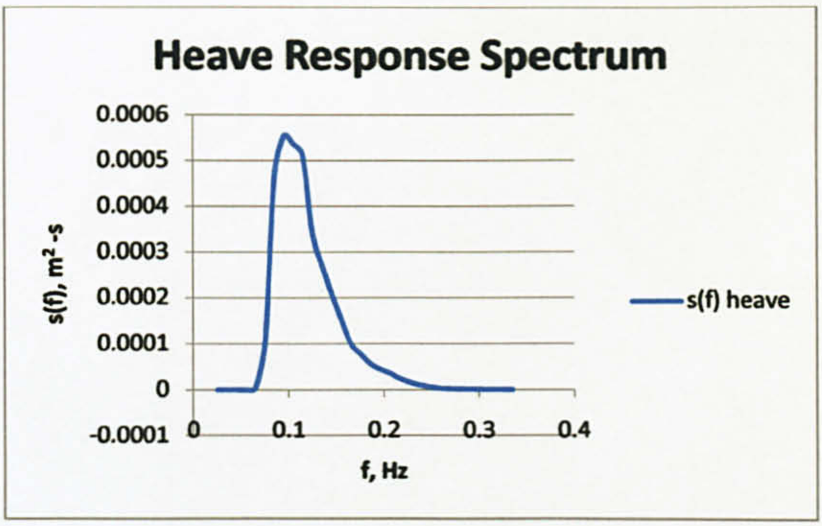

Figure 4.4: Heave Response Spectrum

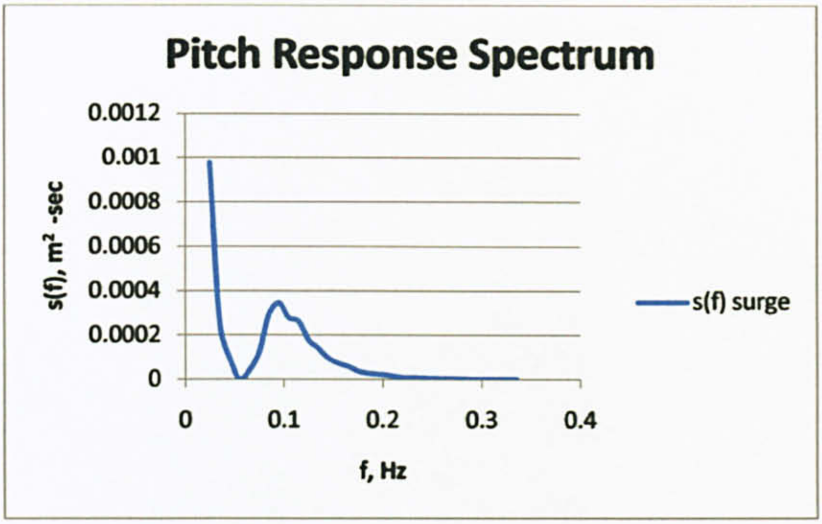

Figure 4.5: Pitch Response Spectrum

4.4 Responses of the Platform on Surge, Heave and Pitch

The calculated responses of the structure are shown in Figure 4.6, 4.7 and 4.8. Refer to Appendix for the calculation detail of motion-response spectrum. The maximum amplitude for the surge motion is 0.5m. The maximum displacement is still restricted by the tethers of the mini-TLP. Meanwhile, the value of displacement for heave and pitch motion are insignificant. The values calculated are very small. This is due to the existence of tethers which is used to restrain the movement of the platform in the y-direction. The heave and pitch movement can even be reduced more by increasing the stiffness of the tethers. This theoretical calculation is proven by the trend of the experimental model responses. For the laboratory works, the pretension of the tethers can be increased by varying the draft of the structure. By reducing the draft, the pretension of the tethers will be increased and thus will cause a smaller movement of the structure. The spreadsheet to generate the time series is attached in APPENDIX I.

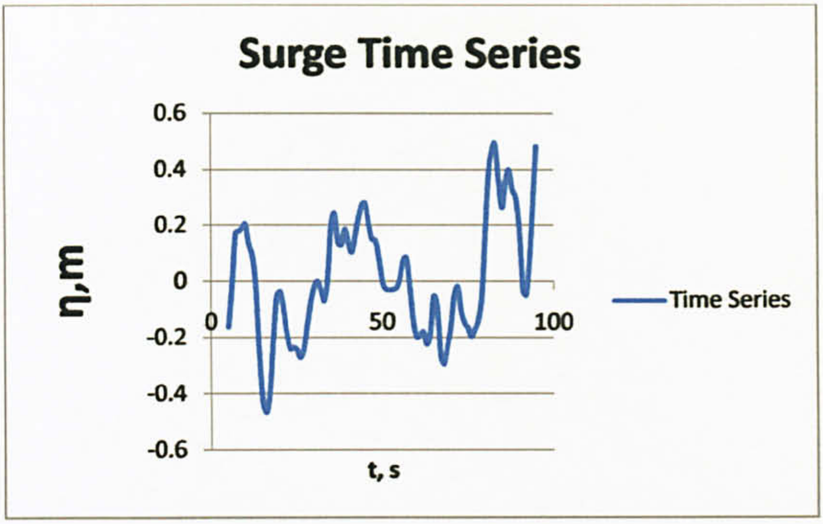

Figure 4.6: Surge Wave Profile

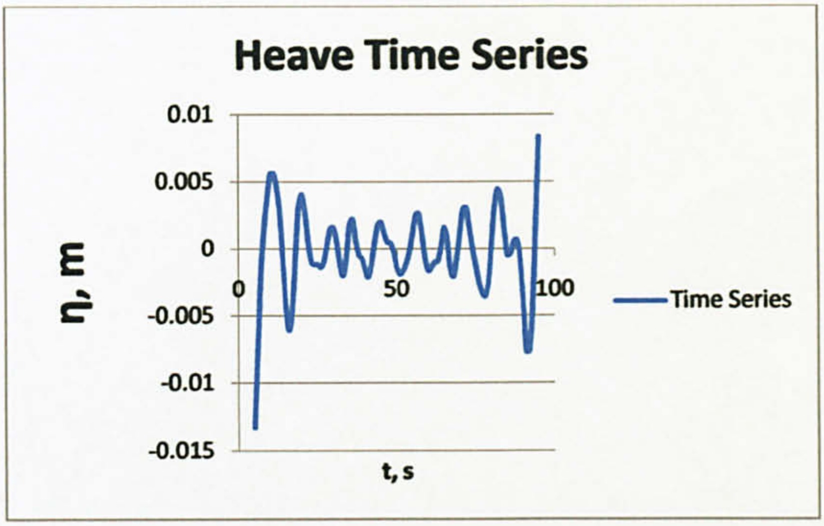

Figure 4.7: Heave Wave Profile

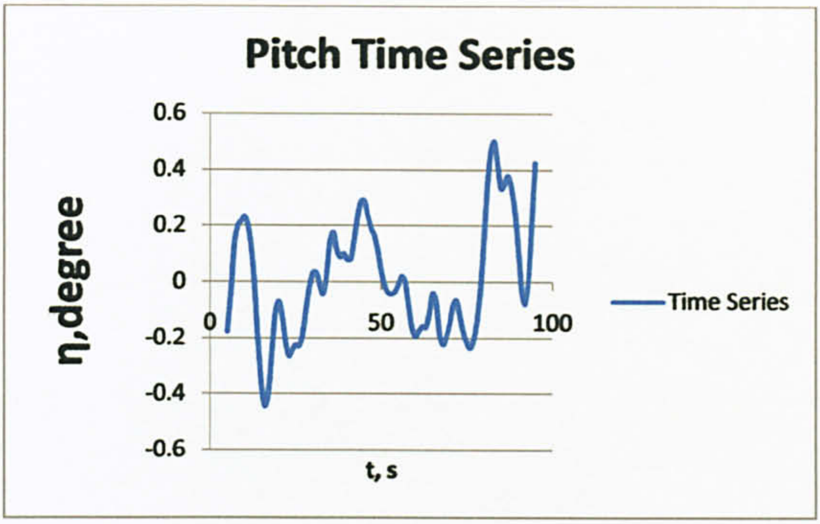

Figure 4.8: Pitch Wave Profile

4.5 Experimental Model Responses

The experiment was done to prove the theoretical calculation. For the experimental observation, only surge (movement on x-axis) and heave (movement on y-axis) can be completed. The movement of the platform was examined by putting up a gridline to the wall of the tank. Surge movement was happened to be very significant which the maximum value of the displacement is 0.035m. Heave movement on the other hand was insignificant. Most of the displacement is moving towards the floor of the tank. The movement upward was almost none which it is due to the existence of the steel chain. The pretension of these tethers can be varied. By increasing the draft (i.e. the depth of hull submerged in water is reduced), the pretension will be reduced and most likely to allow more movement of the structure. Pitch displacement was also seen to be very small. The steel chain once again affects the restrained movement of the platform with respect to pitch. The pretension and the stiffness of the tethers play a vital role in reducing the pitch movement. Lower value of stiffness and pretension of the tethers will allow the structure to move more freely. The graph on the next page shows the surge and heave movement of the platform in the UTP wave tank;

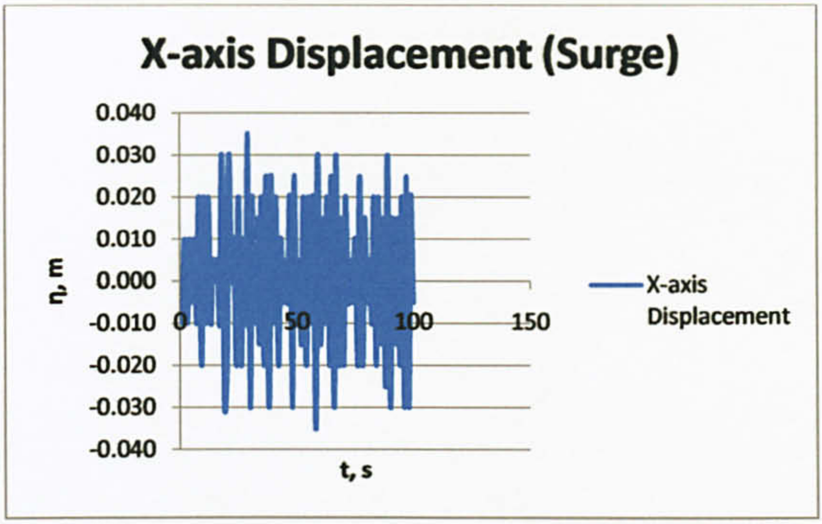

Figure 4.9: Surge Movement of the Experimental Model

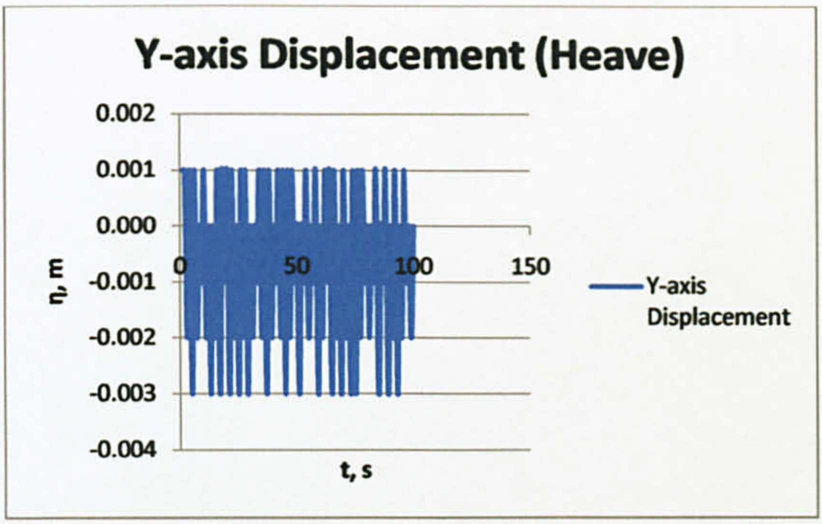

Figure 4.10: Heave Movement of the Experimental Model

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this research, the detailed literature survey about mini-Tension Leg Platform and recent technology of existing Sea Star have been presented. This study developed a simplified manual calculation for the responses of a mini-TLP to random wave loading. The procedures and solutions are using particular spectrum and some mathematical forms. The results highlighted the variation in platform responses caused by the random wave.

The laboratory testing was done successfully in order to prove the theoretical calculation of the platform. The model of the structure movement in the wave tank proves the theoretical calculation where its motion on the x-axis which is surge is very significant and can be clearly seen. It proves the theory where the surge movement of any actual platform is large. However, heave motion is insignificant and the movement is relatively too small. It happens to the actual platform structure. The restricted movement is caused by the tethers and in the case of the platform model; the tethers are replaced by the steel chain. Due to some constraint, pitch movement could not be examined in the laboratory study. However, on the real platform, it is known that the pitch movement of the structure is restricted as well due to the existence of the tethers.

Based on the discussion in the previous sections, some conclusions that can be made are as follows;

- The developed frequency domain dynamic analysis of a mini-TLP is able to predict the responses in surge, heave and pitch degrees of freedom (i.e. the platform is subjected to the random waves) developed from Pierson-Moskowitz Spectrum.
- The maximum amplitude obtained for the surge response is 0.46 m whereas for heave and pitch motion, the value is very small if compared to the surge response. Both values can be neglected.
- Smaller values for heave and pitch are caused by the existence of the tethers that restrain the movement of the mini-TLP in the y-axis as well as the rotation at the x-axis.
- Laboratory works prove the theoretically calculation. The heave value is too small in comparison to the surge movement of the mini-TLP model.
- The results of this frequency domain analysis could be very useful for the preliminary design of any mini-TLP and its components. The responses of the structure gained from the calculation gave an overview of the design condition such as to permit assessment of a complex engineering situation which has associated risk factors.

5.2 Recommendations

Based on the current research, the following recommendations can be taken into account to improve the dynamic analysis and the future works;

- The results obtained from this mini-TLP can be compared with other types of Tension Leg Platform.
- Further refinement needed of the simplified dynamic analysis will be necessary to incorporate nonlinear properties of the mooring line in the frequency domain by the formulation of a stiffness matrix considering mooring line tension fluctuations
- The time history for plotting the waves can be extended to thousand second to obtain random wave.
- Parametric studies can be done in order to study the reaction of the platform on the differences of several parameters such as the draft and the stiffness of the tethers.
- Some modification on the structure model can be implemented such as the weight of the model so that the responses of the structure during the laboratory works can be improved.

CHAPTER 6
ECONOMIC BENEFITS

The inventory of undeveloped deepwater discoveries is the evidence that show the offshore industry's ability to discover deepwater hydrocarbons exceeds its ability to economically exploit them. This inventory, which grow as deepwater wells are drilled, point out the need to develop more economic field development solutions for large and small deepwater fields.

Exploration of deepwater areas of the Gulf of Mexico is focused on the search for major hydrocarbon accumulations, which will materially impact the economic performance of the operators that may afford these ventures. The operation will basically held on a huge reservoir in which will bring back a big profit margin. Previously, early deepwater platform technology is focused on large platforms that could accommodate more than 20 wells. There is less interest in developing methods for smaller discoveries, because small discoveries in frontier areas are considered to be exploration failures.

Conventional deepwater platform technology is based on achieving economies of scale in which the high "fixed" component of cost enables the unit "variable" component of cost to be low. It is often to see the deepwater platform cost is maintained very high while the drilling and completion cost per well is being reduced. However, in fields with a small number of highly productive wells, reducing this variable cost is less important than reducing the fixed cost. An extra burden related with high platform cost is the resultant of the need to drill enough delineation wells to prove up sufficient reserves to cover the large platform investment.

An objective in the development of SeaStar platforms is to reduce platform costs to the extent that many development projects can be economically justified by reserves proved up by a single well. The reduced cost and schedule associated with standardized deepwater platforms can make the difference between years of field development studies and a fast track to first production.

Narrowing deeper into Malaysian context of study, this particular mini-TLP or SeaStar has not being used yet. The nearest oil field that has mini-TLP is in Indonesia. This research is very useful in promoting the use of cost effective platform to make sure the long term oil and gas stock. Recent scenario shows that the source from shallow water area is depleting. There is a must to come out with a strategic solution to work out on the smaller resources especially in those deepwater areas.

Currently, spar is being used in Kikeh. In comparison, SeaStar is more cost-efficient to be used in smaller resources. In current situation where the bigger wells are reducing in the amount and the number of areas itself, a solution in which the usage of SeaStar may be proposed. This study is the base for the analysis of behaviour of SeaStar in Malaysian environment and can be expanded to search for ways to reduce platform size and cost such that competitive Gulf of Mexico infrastructure. Substantial parts of previous deepwater projects were built in Europe or the Far East and then transported to the Gulf of Mexico. Tension leg mooring technology is used as the means to reduce platform size and increase transparency to environmental forces while maintaining platform stability in deepwater and the suitability of design in Malaysian deepwater environment must be studied.

The study can also be stretched to locating the production facility close to subsea wells, and shortening flow lines and umbilical, provide operational and cost advantages, while keeping the platform to well interfaces simple. A deepwater platform that reduces flow line/umbilical length and provides stand-alone processing is a vital aspect in the deepwater technology. A small, strategically-located, deepwater platform also extends pipeline infrastructure and enhances the economic potential of smaller fields in that area and the information gathered might be very useful for the development of deepwater technology in Malaysia.

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APPENDICES

APPENDIX A

No	Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue								M							
	a. Surge Analysis								I							
	b. Heave Analysis								D							
2	Submission of Progress Report															
3	Project Work Continue								S							
	c. Pitch Analysis								E							
	d. Model Testing								M							
4	Seminar								E							
5	Project Work Continue								S							
6	Poster Exhibition								T							
7	Submission of Dissertation (soft bound)								E							
8	Oral Presentation								R							
9	Submission of Project Dissertation (hard bound)															

Completed

To be completed

APPENDIX B

WAVE FORCES CALCULATION

By using MORISON EQUATION

Inertia Force	Drag Force
$df_I = C_M \rho \frac{\pi}{4} D^2 \frac{\delta u}{\delta t} ds$	$df_D 0.5 C_D \rho D \lvert u \rvert u ds$
Total Force	
$F_t = df_I + df_D$	

T=40					T=28					T=22					TOTAL			
t	Fx	Fy	Fz		t	Fx	Fy	Fz		t	Fx	Fy	Fz		t	Fx	Fy	Fz
0.00	251614	-2.3E-79	0		0.00	251614	-7.6E-16	0		0.00	251614	-0.10202	0		0.00	251663.7	-3102.21	0
2.00	251614	-2.2E-79	0		1.00	251614	-7.4E-16	0		1.00	251614	-0.09945	0		1.00	250986.7	-2985.16	0
4.00	251614	-1.9E-79	0		2.00	251614	-7E-16	0		2.00	251614	-0.08883	0		2.00	250385.4	-2508.07	0
6.00	251614	-1.4E-79	0		3.00	251614	-6.1E-16	0		3.00	251614	-0.07101	0		3.00	249932.2	-1728.48	0
8.00	251614	-8.1E-80	0		4.00	251614	-5E-16	0		4.00	251614	-0.04743	0		4.00	249682	-740.401	0
10.00	251614	-9.9E-81	0		5.00	251614	-3.6E-16	0		5.00	251613.9	-0.02002	0		5.00	249664.7	336.9833	0
12.00	251614	6.18E-80	0		6.00	251614	-2E-16	0		6.00	251613.9	0.009018	0		6.00	249882.6	1373.729	0
14.00	251614	1.28E-79	0		7.00	251614	-3.5E-17	0		7.00	251613.9	0.037324	0		7.00	250309.3	2244.786	0
16.00	251614	1.81E-79	0		8.00	251614	1.34E-16	0		8.00	251614	0.062607	0		8.00	250893.4	2845.084	0

18.00	251614	2.16E-79	0
20.00	251614	2.31E-79	0
22.00	251614	2.22E-79	0
24.00	251614	1.92E-79	0
26.00	251614	1.44E-79	0
28.00	251614	8.07E-80	0
30.00	251614	9.91E-81	0
32.00	251614	-6.2E-80	0
34.00	251614	-1.3E-79	0
36.00	251614	-1.8E-79	0
38.00	251614	-2.2E-79	0
40.00	251614	-2.3E-79	0
MAX	251614	2.31E-79	0

9.00	251614	2.97E-16	0
10.00	251614	4.44E-16	0
11.00	251614	5.69E-16	0
12.00	251614	6.66E-16	0
13.00	251614	7.29E-16	0
14.00	251614	7.55E-16	0
15.00	251614	7.44E-16	0
16.00	251614	6.96E-16	0
17.00	251614	6.12E-16	0
18.00	251614	4.98E-16	0
19.00	251614	3.59E-16	0
20.00	251614	2.02E-16	0
21.00	251614	3.45E-17	0
22.00	251614	-1.3E-16	0
23.00	251614	-3E-16	0
24.00	251614	-4.4E-16	0
25.00	251614	-5.7E-16	0
26.00	251614	-6.7E-16	0
27.00	251614	-7.3E-16	0
28.00	251614	-7.6E-16	0
MAX	251614	7.55E-16	0

9.00	251614	0.082817	0
10.00	251614	0.096319	0
11.00	251614	0.102017	0
12.00	251614	0.09945	0
13.00	251614.1	0.088826	0
14.00	251614.1	0.071007	0
15.00	251614.1	0.047434	0
16.00	251614.1	0.020019	0
17.00	251614.1	-0.00902	0
18.00	251614.1	-0.03732	0
19.00	251614.1	-0.06261	0
20.00	251614.1	-0.08282	0
21.00	251614	-0.09632	0
22.00	251614	-0.10202	0
MAX	251614.1	0.102017	0

9.00	251564.4	3102.212	0
10.00	252241.4	2985.163	0
11.00	252842.7	2508.072	0
12.00	253295.8	1728.477	0
13.00	253546.1	740.4012	0
14.00	253563.3	-336.983	0
15.00	253345.5	-1373.73	0
16.00	252918.8	-2244.79	0
17.00	252334.7	-2845.08	0
18.00	251663.7	-3102.21	0
MAX	253563.3	3102.212	0

T=15			
t	Fx	Fy	Fz
0.00	251200.3	-182590	0
1.00	210626.4	-172853	0
2.00	177136.9	-133265	0
3.00	156532.6	-70648.5	0
4.00	152384.6	4196.266	0
5.00	165410.8	78337.37	0
6.00	193351.8	138942.5	0
7.00	231365.8	175505.6	0
8.00	272872.9	181686.7	0
9.00	310697.7	156475.1	0
10.00	338308.5	104234.8	0
11.00	350941.4	33971.15	0
12.00	346417	-42186.2	0
13.00	325514.1	-111067	0
14.00	291837.3	-160741	0
15.00	251200.3	-182590	0
MAX	350941.4	181686.7	0

T=13			
t	Fx	Fy	Fz
0.00	235914.1	-1123208	0
1.00	-23406.3	-1046283	0
2.00	-219756	-730901	0
3.00	-307783	-248305	0
4.00	-267121	291842.5	0
5.00	-107229	765738.9	0
6.00	134900.7	1063853	0
7.00	403530.4	1117029	0
8.00	637177.3	915076.6	0
9.00	782650	504301.6	0
10.00	806944.8	-22308.8	0
11.00	704528.3	-544586	0
12.00	498576.7	-942300	0
13.00	235914.1	-1123208	0
MAX	806944.8	1117029	0

T=11			
t	Fx	Fy	Fz
0.00	167008.6	-2975231	0
1.00	-574418	-2709390	0
2.00	-1053300	-1590733	0
3.00	-1115164	33613.89	0
4.00	-740122	1652323	0
5.00	-49474	2746445	0
6.00	735406.6	2961128	0
7.00	1365811	2240314	0
8.00	1644091	812034.1	0
9.00	1483485	-878004	0
10.00	933808.4	-2292852	0
11.00	167008.6	-2975231	0
MAX	1644091	2961128	0

T=10.5			
t	Fx	Fy	Fz
0.00	114653.1	-4182333	0
1.00	-957781	-3783489	0
2.00	-1609074	-2083706	0
3.00	-1608203	341602.5	0
4.00	-955734	2659299	0
5.00	116707.6	4048822	0
6.00	1233125	4018895	0
7.00	2008003	2605463	0
8.00	2177157	288460.3	0
9.00	1683064	-2138411	0
10.00	693251.8	-3823531	0
11.00	-452613	-4165815	0
MAX	2177157	4048822	0

T=10			
t	Fx	Fy	Fz
0.00	65989.36	-4872649	0
1.00	-1225035	-4375514	0
2.00	-1950459	-2224940	0
3.00	-1827044	780206.6	0
4.00	-903435	3498971	0
5.00	460495.9	4872649	0
6.00	1740903	4375514	0
7.00	2454023	2224940	0
8.00	2333621	-780207	0
9.00	1424178	-3498971	0
10.00	65989.36	-4872649	0
MAX	2454023	4872649	0

T=9			
t	Fx	Fy	Fz
0.00	-44104.6	-5688280	0
1.00	-1678622	-5025173	0
2.00	-2406473	-2032027	0
3.00	-1879598	1921987	0
4.00	-350312	4986661	0
5.00	1456317	5696687	0
6.00	2697432	3754318	0
7.00	2802663	61311.62	0
8.00	1723885	-3676774	0
9.00	-44104.6	-5688280	0
MAX	2802663	5696687	0

T=8.5			
t	Fx	Fy	Fz
0.00	-100790	-5770905	0
1.00	-1842942	-5054083	0
2.00	-2487337	-1719326	0
3.00	-1690662	2524747	0
4.00	123074.9	5456648	0
5.00	1998682	5520215	0
6.00	2963722	2722049	0
7.00	2524133	-1501941	0
8.00	904560.4	-4954290	0
9.00	-1060167	-5800692	0
MAX	2963722	5520215	0

T=8			
t	Fx	Fy	Fz
0.00	256059.8	-5718842	0
1.00	-1737501	-4965883	0
2.00	-2561424	-1322040	0
3.00	-1726106	3108976	0
4.00	269450.1	5718842	0
5.00	2249315	4965883	0
6.00	3063395	1322040	0
7.00	2241773	-3108976	0
8.00	-876.099	-5718842	0
MAX	3063395	5718842	0

T=7.5			
t	Fx	Fy	Fz
0.00	-227413	-5605026	0
1.00	-2133271	-4829277	0
2.00	-2454740	-873349	0
3.00	-975059	3673291	0
4.00	1314772	5783055	0
5.00	2897925	4063856	0
6.00	2738931	-335188	0
7.00	942015.8	-4525967	0
8.00	-1315689	-5707748	0
MAX	2897925	5783055	0

T=7			
t	Fx	Fy	Fz
0.00	-305941	-5467667	0
1.00	-2301120	-4681825	0
2.00	-2366879	-383444	0
3.00	-451899	4215723	0
4.00	1989205	5629817	0
5.00	3122035	2811675	0
6.00	2104452	-2125344	0
7.00	-305941	-5467667	0
MAX	3122035	5629817	0

T=6.5			
t	Fx	Fy	Fz
0.00	-401456	-5319346	0
1.00	-2504076	-4542192	0
2.00	-2217951	148356.2	0
3.00	208738.7	4721240	0
4.00	2667649	5204510	0
5.00	3044115	1202347	0
6.00	1018169	-3847305	0
7.00	-1673273	-5566338	0
MAX	3044115	5204510	0

T=6			
t	Fx	Fy	Fz
0.00	-519737	-5155210	0
1.00	-2753921	-4418248	0
2.00	-1973265	728895.9	0
3.00	1037115	5155210	0
4.00	3257561	4418248	0
5.00	2481365	-728896	0
6.00	-519737	-5155210	0
MAX	3257561	5155210	0

T=5.8			
t	Fx	Fy	Fz
0.00	-517058	-4722325	0
1.00	-2649378	-4064575	0
2.00	-1688973	908403.6	0
3.00	1337878	4921486	0
4.00	3206671	3696774	0
5.00	1942921	-1453282	0
6.00	-1117268	-5062654	0
MAX	3206671	4921486	0

T=5.5			
t	Fx	Fy	Fz
0.00	-564874	-4395414	0
1.00	-2689584	-3826439	0
2.00	-1367290	1211763	0
3.00	1849352	4836942	0
4.00	3196632	2804451	0
5.00	1109830	-2505531	0
6.00	-1982044	-4885656	0
MAX	3196632	4836942	0

T=5			
t	Fx	Fy	Fz
0.00	-730874	-4149491	0
1.00	-3033448	-3757142	0
2.00	-787058	1824642	0
3.00	2893968	4886007	0
4.00	2926245	1195737	0
5.00	-730874	-4149491	0
MAX	2926245	4886007	0

T=4.8			
t	Fx	Fy	Fz
0.00	-739072	-3754015	0
1.00	-2967295	-3490953	0
2.00	-415711	1945083	0
3.00	3123713	4498198	0
4.00	2409979	384409.4	0
5.00	-1499194	-4301489	0
MAX	3123713	4498198	0

T=4.6			
t	Fx	Fy	Fz
0.00	-749573	-3374165	0
1.00	-2914084	-3253683	0
2.00	-27976.9	2049027	0
3.00	3301873	4087444	0
4.00	1777737	-384805	0
5.00	-2176118	-4245415	0
MAX	3301873	4087444	0

T=4.4			
t	Fx	Fy	Fz
0.00	-761153	-3001391	0
1.00	-2870979	-3040634	0
2.00	382184.4	2135292	0
3.00	3409711	3648248	0
4.00	1025766	-1096218	0
5.00	-2686438	-3960774	0
MAX	3409711	3648248	0

T=4.2			
t	Fx	Fy	Fz
0.00	-771980	-2627263	0
1.00	-2834547	-2847360	0
2.00	819762.8	2201435	0
3.00	3421327	3176269	0
4.00	162943.9	-1726419	0
5.00	-2932476	-3434327	0
MAX	3421327	3176269	0

T=4			
t	Fx	Fy	Fz
0.00	-779386	-2243664	0
1.00	-2800527	-2669528	0
2.00	1287664	2243664	0
3.00	3302944	2669528	0
4.00	-779386	-2243664	0
MAX	3302944	2669528	0

T=3.9			
t	Fx	Fy	Fz
0.00	-733984	-1953353	0
1.00	-2645229	-2467800	0
2.00	1474758	2152170	0
3.00	3049538	2294540	0
4.00	-1192725	-2337023	0
MAX	3049538	2294540	0

T=3.7			
t	Fx	Fy	Fz
0.00	-730367	-1563543	0
1.00	-2610313	-2315574	0
2.00	1964211	2151957	0
3.00	2678794	1769052	0
4.00	-2074566	-2601416	0
MAX	2678794	2151957	0

T=3.6			
t	Fx	Fy	Fz
0.00	-681925	-1302155	0
1.00	-2467442	-2145537	0
2.00	2132455	2047468	0
3.00	2318093	1434621	0
4.00	-2344667	-2545710	0
MAX	2318093	2047468	0

T=3.5			
t	Fx	Fy	Fz
0.00	-633298	-1056824	0
1.00	-2332487	-1989788	0
2.00	2289034	1942523	0
3.00	1929860	1125440	0
4.00	-2531049	-2443349	0
MAX	2289034	1942523	0

T=3.4					T=3.2					T=3.1					T=3			
t	Fx	Fy	Fz		t	Fx	Fy	Fz		t	Fx	Fy	Fz		t	Fx	Fy	Fz
0.00	-583575	-825892	0		0.00	-535759	-436692	0		0.00	-471335	-230725	0		0.00	-402690	-42308.4	0
1.00	-2203248	-1845880	0		1.00	-2130538	-1712224	0		1.00	-1990915	-1578098	0		1.00	-1849350	-1449034	0
2.00	2432460	1836325	0		2.00	2863840	1747256	0		2.00	2951113	1620746	0		2.00	3008031	1491364	0
3.00	1513900	840947.2	0		3.00	635822.4	375019.7	0		3.00	117751.2	150615.9	0		3.00	-402690	-42308.4	0
4.00	-2618882	-2296529	0		4.00	-2653620	-2034212	0		4.00	-2328909	-1753359	0		MAX	3008031	1491364	0
MAX	2432460	1836325	0		MAX	2863840	1747256	0		MAX	2951113	1620746	0					

WAVE SPECTRUM CALCULATION

f	ω	ω/ω_0	s(ω)	s(f)	H(f)	Rn	εn
0.005	0.031416	0.047438	0	0	0	0.271226	1.70416
0.015	0.094248	0.142314	0	0	0	0.107877	0.67781
0.025	0.15708	0.237191	2.5E-168	1.6E-167	1.12E-84	0.302607	1.901333
0.035	0.219911	0.332067	3.42E-42	2.15E-41	1.31E-21	0.208273	1.308616
0.045	0.282743	0.426943	1.98E-14	1.24E-13	9.97E-08	0.603417	3.791383
0.055	0.345575	0.52182	7.54E-06	4.73E-05	0.001946	0.050493	0.317254
0.065	0.408407	0.616696	0.0121	0.076028	0.077989	0.685826	4.309169
0.075	0.471239	0.711572	0.255769	1.607043	0.358557	0.94934	5.964878
0.085	0.534071	0.806449	0.933379	5.864591	0.684958	0.441723	2.775428
0.095	0.596903	0.901325	1.546846	9.719123	0.881777	0.158102	0.993384
0.105	0.659734	0.996201	1.751802	11.00689	0.938377	0.777241	4.883547
0.115	0.722566	1.091078	1.637094	10.28616	0.907135	0.695161	4.367825
0.125	0.785398	1.185954	1.385647	8.706274	0.834567	0.512824	3.222165
0.135	0.84823	1.28083	1.114931	7.005318	0.748616	0.710665	4.465238
0.145	0.911062	1.375707	0.875437	5.500532	0.663357	0.438764	2.756835
0.155	0.973894	1.470583	0.680604	4.276358	0.584901	0.538289	3.382171
0.165	1.036726	1.565459	0.528221	3.318912	0.51528	0.345371	2.170029
0.175	1.099557	1.660336	0.411151	2.583341	0.454607	0.674992	4.241098
0.185	1.162389	1.755212	0.321789	2.021859	0.40218	0.627627	3.943494
0.195	1.225221	1.850088	0.253581	1.593299	0.357021	0.049332	0.309963

0.205	1.288053	1.944965	0.201336	1.265033	0.318124	0.129624	0.814452
0.215	1.350885	2.039841	0.161094	1.012184	0.284561	0.313335	1.968744
0.225	1.413717	2.134717	0.129889	0.816117	0.255518	0.474704	2.982651
0.235	1.476549	2.229594	0.105516	0.662979	0.2303	0.677328	4.255774
0.245	1.53938	2.32447	0.086338	0.542477	0.208322	0.983715	6.180861
0.255	1.602212	2.419346	0.071135	0.446952	0.189093	0.225307	1.415644
0.265	1.665044	2.514223	0.058995	0.370674	0.172203	0.733858	4.610967
0.275	1.727876	2.609099	0.049232	0.309335	0.157311	0.14583	0.916276
0.285	1.790708	2.703975	0.041328	0.259673	0.144131	0.225492	1.41681
0.295	1.85354	2.798852	0.034888	0.219205	0.132425	0.179885	1.130249
0.305	1.916372	2.893728	0.029606	0.186023	0.121991	0.721186	4.531348
0.315	1.979203	2.988604	0.02525	0.158653	0.11266	0.419234	2.634126
0.325	2.042035	3.08348	0.021637	0.135952	0.104289	0.798228	5.015412
0.335	2.104867	3.178357	0.018624	0.117021	0.096756	0.645543	4.056067
0.345	2.167699	3.273233	0.016099	0.101154	0.089957	0.263413	1.655072
0.355	2.230531	3.368109	0.013972	0.08779	0.083805	0.669255	4.205056
0.365	2.293363	3.462986	0.012173	0.076484	0.078222	0.907585	5.702523
0.375	2.356194	3.557862	0.010643	0.066875	0.073144	0.587215	3.689584
0.385	2.419026	3.652738	0.009338	0.058675	0.068513	0.082941	0.521133
0.395	2.481858	3.747615	0.00822	0.05165	0.064281	0.053805	0.338064

WAVE PROFILE CALCULATION

t	η23	η24	η25	η26	η27	η28	η29	η30	η31	η32	η33	η34	η35	η36	η37	η38	η39	η40	η
0	-0.12615	-0.05077	0.103616	0.01461	-0.00872	0.047884	0.011053	0.028235	-0.01098	-0.04929	0.01556	-0.02952	-0.00379	-0.02036	0.032701	-0.03122	0.029709	0.130321	[illegible]
1	0.000238	-0.10767	-0.00738	0.092906	-0.08446	0.054142	0.067087	0.049635	-0.05273	0.044675	-0.05141	-0.01796	0.039197	-0.01646	-0.03772	0.008601	-0.01101	-0.01742	[illegible]
2	0.126228	0.030505	-0.10408	-0.02045	0.024614	-0.06482	-0.04032	-0.05593	0.046707	0.013746	0.031118	0.047808	-0.04028	0.040537	0.017188	0.019059	-0.0132	-0.00278	[illegible]
3	0.090253	0.113414	0.000841	-0.09162	0.079826	-0.03386	-0.04949	-0.01843	0.021089	-0.05559	0.028154	-0.03071	0.006082	-0.03823	0.014986	-0.03558	0.030805	0.121825	0.452958
4	-0.11394	-0.00916	0.104133	0.026203	-0.03964	0.075417	0.061916	0.066213	-0.06099	0.030412	-0.05214	-0.01654	0.033441	0.000196	-0.03701	0.031217	-0.03302	-0.03171	1.115204
5	-0.0749	-0.11514	0.0057	0.089975	-0.07237	0.010265	0.022481	-0.01852	0.020233	0.031439	0.034189	0.047552	-0.04367	0.032989	0.038963	-0.0086	0.018728	0.02828	[illegible]
6	0.090507	-0.01251	-0.10877	-0.03185	0.058259	-0.07963	-0.07172	-0.05588	0.047286	-0.05538	0.030179	-0.03187	0.015657	-0.04063	-0.00791	-0.01905	0.004921	-0.01299	[illegible]
7	0.103219	0.112783	-0.01222	-0.08797	0.062941	0.014336	0.008811	0.049698	-0.05227	0.012552	-0.05159	-0.01511	0.026074	0.016821	-0.0235	0.035546	-0.02611	-0.00776	[illegible]
8	-0.05821	0.03374	0.103007	0.037382	-0.06499	0.074143	0.06788	0.028149	-0.01188	0.045412	0.016665	0.047249	-0.04497	0.020015	0.038992	-0.03122	0.034251	0.125247	[illegible]
9	-0.12143	-0.10643	0.018691	0.085626	-0.05011	-0.03753	-0.03843	-0.0654	0.060314	-0.04862	0.036459	-0.033	0.024478	-0.04136	-0.02807	0.008601	-0.02527	-0.03214	[illegible]
10	0.020221	-0.05377	-0.10183	-0.04276	0.074424	-0.0624	-0.05112	0.008346	-0.02899	-0.00679	-0.04977	-0.01366	0.017451	0.030679	-0.00186	0.019059	0.000665	0.125543	[illegible]
11	0.127759	0.096312	-0.02509	-0.08294	0.0361	0.057056	0.060727	0.060748	-0.04068	0.054017	0.00873	0.046899	-0.0441	0.003748	0.030536	-0.03555	0.019775	-0.00823	[illegible]
12	0.019751	0.071899	0.100257	0.047971	-0.08122	0.04465	0.024621	-0.04224	0.056543	-0.03611	0.041842	-0.03409	0.03212	-0.03527	-0.03853	0.031217	-0.03333	-0.01254	[illegible]
13	-0.12158	-0.08278	0.031386	0.079926	-0.02081	-0.07099	-0.07147	-0.03718	0.00297	-0.02533	-0.04672	-0.01219	0.007987	0.039491	0.020418	-0.0086	0.03023	0.128048	[illegible]
14	-0.05779	-0.08748	-0.09828	-0.05299	0.085136	-0.02294	0.00656	0.062987	-0.05815	0.056235	0.000581	0.046503	-0.0411	-0.01313	0.01152	-0.01905	-0.01202	-0.03178	[illegible]
15	0.109499	0.066314	-0.03756	-0.0766	0.00479	0.077983	0.069607	0.002032	0.037024	-0.01934	0.046194	-0.03515	0.038215	-0.02839	-0.03565	0.035546	-0.0122	0.122177	[illegible]
16	0.090171	0.099961	0.095925	0.057804	-0.08604	-0.00206	-0.03649	-0.06412	0.033066	-0.04088	-0.04252	-0.01071	-0.00186	0.041807	0.035637	-0.03122	0.030919	-0.00326	[illegible]
17	-0.07529	-0.0475	0.048587	0.072965	0.011404	-0.07734	-0.05269	0.039746	-0.05943	0.051804	-0.00758	0.046061	-0.03612	-0.02786	-0.01148	0.008601	-0.03929	-0.01702	[illegible]
18	-0.11379	-0.1089	-0.09319	-0.06239	0.083891	0.026257	0.059479	0.045291	0.007193	-0.00027	0.04941	-0.03618	0.042469	-0.00766	-0.02045	0.019059	0.01962	0.130158	[illegible]
19	0.039706	0.027003	-0.0444	-0.06905	-0.02719	0.069129	0.026736	-0.05902	0.054552	-0.05159	-0.03728	-0.00929	-0.01162	0.037246	0.038532	-0.03555	0.003853	-0.03064	[illegible]
20	0.126149	0.113984	0.090081	0.066725	-0.07877	-0.04798	-0.07114	-0.01286	-0.04415	0.041248	-0.01556	0.046573	-0.02941	-0.038	-0.03051	0.031217	-0.0254	0.118265	[illegible]
21	-0.00024	-0.00555	0.0551	0.064854	0.04202	-0.05414	0.004303	0.065914	-0.02464	0.018826	0.051408	-0.03717	0.044678	0.009832	0.001822	-0.0086	0.034254	0.101777	[illegible]
22	-0.12622	-0.11503	-0.08662	-0.0708	0.070864	0.064823	0.069266	-0.02442	0.060845	-0.0562	-0.03112	-0.00773	-0.02082	0.026558	0.028101	-0.01905	-0.02599	-0.02107	[illegible]

23	-0.03925	-0.0161	-0.06054	-0.06041	-0.05536	0.033861	-0.09452	-0.05229	-0.01658	0.025814	-0.02315	0.045041	-0.02127	-0.04189	-0.03899	0.035546	0.004733	0.031525	0.19491
24	0.113942	0.111998	0.082816	0.074595	-0.06044	-0.07542	-0.0542	0.053595	-0.04961	0.035697	0.052141	-0.03812	0.044735	0.024788	0.029466	-0.03122	0.018887	-0.02875	0.182123
25	0.074902	0.097181	0.065744	0.05572	0.066734	-0.01026	0.058171	0.022984	0.050191	-0.05417	-0.02419	-0.00628	-0.02901	0.011502	0.007952	0.008601	-0.03907	0.013903	0.346436
26	-0.09051	-0.105	-0.07869	-0.07809	0.047884	0.078629	0.028825	-0.06608	0.015609	0.007929	-0.03018	0.044464	-0.01212	-0.03889	-0.03398	0.019059	0.030721	0.006775	0.472152
27	-0.10322	-0.05694	-0.07069	-0.05081	-0.07575	-0.01434	-0.07075	0.014491	-0.06077	0.048847	0.05159	-0.03904	0.042636	0.036167	0.036996	-0.03555	-0.01302	-0.02461	-0.14836
28	0.056213	0.094282	0.074246	0.061287	-0.03368	-0.07414	0.002041	0.057999	0.025558	-0.04673	-0.01666	-0.00472	-0.03581	-0.00545	-0.01485	0.031217	-0.01119	0.032116	0.119508
29	0.121432	0.074689	0.075852	0.045708	0.082076	0.037539	0.069857	-0.04685	0.049451	-0.01202	-0.09646	0.048844	-0.00238	-0.02949	-0.01723	-0.0086	0.029803	-0.02614	0.467144
30	-0.02022	-0.08022	-0.06931	-0.08416	0.018179	0.062401	-0.08252	-0.03186	-0.055	0.058281	0.049769	-0.03992	0.038485	0.041596	0.03773	-0.01905	-0.03353	0.009198	-0.00529
31	-0.12776	-0.08979	-0.07972	-0.04042	-0.0855	-0.05706	-0.05567	0.064628	-0.00619	-0.03189	-0.00873	-0.0032	-0.04089	-0.0215	-0.03268	0.035546	0.020492	0.011607	-0.44123
32	-0.01875	0.063924	0.064504	0.086698	-0.00209	-0.04455	0.056806	-0.00421	0.059191	-0.03985	-0.04184	0.04318	0.007479	-0.01524	0.00549	-0.03122	0.002782	-0.02754	-0.4061
33	0.121579	0.101707	0.083771	0.034974	0.085891	0.070994	0.030886	-0.06228	-0.03991	0.053578	0.046722	-0.04076	0.032479	0.040183	0.025416	0.008601	-0.02467	0.031916	-0.0009
34	0.057789	-0.04418	-0.05924	-0.0989	-0.01408	0.022938	-0.07028	0.038958	-0.09622	-0.01427	-0.00058	-0.00168	-0.04399	-0.03401	-0.03911	0.019059	0.034223	-0.0229	-0.40298
35	-0.1085	-0.11002	-0.08749	-0.02939	-0.08824	-0.07796	-0.00022	0.040544	0.058445	-0.04434	-0.04619	0.042479	0.016974	0.001512	0.028307	-0.03555	-0.02668	0.004268	0.004144
36	-0.09017	0.029473	0.053745	0.090741	0.029746	0.002061	0.070378	-0.06158	-0.0399	0.049492	0.042524	-0.04156	0.02491	0.032161	0.004312	0.031217	0.005796	0.018152	0.871793
37	0.075287	0.114441	0.090869	0.029689	0.077642	0.077398	-0.03048	-0.00618	-0.05616	0.005031	0.007589	-0.00017	-0.04498	-0.04094	-0.03201	-0.0086	0.01798	-0.02979	0.481529
38	0.113726	-0.00193	-0.04804	-0.09229	-0.04436	-0.02626	-0.05708	0.063031	0.041422	-0.05349	-0.04941	0.041726	0.025651	0.018018	0.038025	-0.01905	-0.03277	0.030931	-0.32298
39	-0.03971	-0.1149	-0.03889	-0.0179	-0.06929	-0.06912	0.055285	-0.0301	0.028096	0.037455	0.03729	-0.04231	0.01614	0.018848	-0.01828	0.035546	0.031182	-0.01909	-0.91729
40	-0.12615	-0.01967	0.042139	0.098934	0.057402	0.047884	0.032916	-0.04823	-0.05046	0.023739	0.01556	0.001355	-0.0489	-0.04112	-0.01384	-0.03122	-0.01401	-0.00077	-0.76004
41	0.000238	0.111102	0.066534	0.012031	0.058489	0.054142	-0.06975	0.057016	0.012862	-0.05631	-0.05141	0.040935	0.033099	0.031561	0.036593	0.008601	-0.01016	0.0209	0.212768
42	0.126229	0.040586	-0.03607	-0.09411	-0.06841	-0.06482	-0.00249	0.01642	0.051742	0.020988	0.031118	-0.04808	0.006593	0.002435	-0.03456	0.019059	0.029258	-0.03131	0.450695
43	0.039253	-0.10946	-0.0988	-0.00612	-0.04561	-0.03986	0.070831	-0.06618	-0.04792	0.038639	0.029154	0.002873	-0.0405	-0.03455	0.00911	-0.03555	-0.03973	0.029183	1.03173
44	-0.11394	-0.06006	0.029867	0.094494	0.076995	0.075417	-0.02842	0.020506	-0.01928	-0.05247	-0.05214	0.040105	0.038941	0.038912	0.022506	0.031217	0.021344	-0.01481	1.349404
45	-0.0749	0.092159	0.100676	0.000182	0.031121	0.010265	-0.05843	0.054736	0.060978	0.00204	0.024189	-0.0437	-0.00327	-0.01438	-0.03888	-0.0086	0.001708	-0.00579	0.968168
46	0.090507	0.077405	-0.02354	-0.09451	-0.08285	-0.07863	0.05391	-0.05105	-0.02208	0.030853	0.030178	0.004388	-0.03526	-0.02229	0.028914	-0.01905	-0.02891	0.029948	-1.01836
47	0.103219	-0.07759	-0.10216	0.005755	-0.01559	0.014896	0.034913	-0.02625	-0.04605	-0.04243	-0.05159	0.039235	0.042914	0.041697	0.000635	0.035546	0.034158	-0.03206	-1.56242
48	-0.05821	-0.09201	0.017125	0.094144	0.085775	0.074143	-0.06914	0.065696	0.05323	-0.01715	0.016665	-0.04439	-0.01298	-0.02893	-0.02975	-0.03122	-0.02734	0.026718	-1.22442

49	-0.12149	0.060272	0.108231	-0.01167	-0.00062	-0.03753	-0.00475	-0.01041	0.009991	0.056054	0.036459	0.0059	-0.02832	-0.00636	0.038718	0.008601	0.006854	-0.01016	[illegible]
50	0.020221	0.109353	-0.01064	-0.09941	-0.08586	-0.0624	0.071213	-0.05989	-0.06	-0.02737	-0.04977	0.038827	0.044819	0.096624	-0.02146	0.019053	0.017055	-0.01066	[illegible]
51	0.127759	-0.04082	-0.1099	0.017537	0.01674	0.057056	-0.02632	0.043823	0.090657	-0.09431	0.00873	-0.04492	-0.02206	-0.09853	-0.01034	-0.03555	-0.03244	0.027007	[illegible]
52	0.019751	-0.11104	0.004113	0.092909	0.082508	0.04465	-0.05973	0.085438	0.089229	0.054627	0.041842	0.007405	-0.02002	0.01061	0.035132	0.031217	0.031612	-0.03202	[illegible]
53	-0.12158	0.019921	0.104158	-0.02394	-0.03227	-0.07099	0.052381	-0.0636	-0.05723	-0.00908	-0.04672	0.087381	0.044566	0.025527	-0.03613	-0.0086	-0.01499	0.023594	[illegible]
54	-0.05779	0.114785	0.002431	-0.09084	-0.07649	-0.02294	0.096876	4.79E-05	-0.00045	-0.04742	0.000581	-0.04546	-0.03008	-0.0419	0.012649	-0.01905	-0.00913	-0.00527	[illegible]
55	0.103499	0.001684	-0.10401	0.029049	0.046656	0.077989	-0.06847	0.06357	0.037542	0.046741	0.046194	0.008908	-0.01075	0.025837	0.019396	0.035546	0.028684	-0.01527	[illegible]
56	0.090171	-0.11447	-0.00896	0.089019	0.067659	-0.00206	-0.007	-0.03552	-0.09853	0.010289	-0.04252	0.036398	0.042165	0.010231	-0.0383	-0.03122	-0.0389	0.0294	[illegible]
57	-0.07529	-0.02929	0.108442	-0.09464	-0.05939	-0.07734	0.071525	-0.04375	-0.09144	-0.05491	-0.00758	-0.04596	-0.03665	-0.03839	0.031264	0.008601	0.022176	-0.03119	[illegible]
58	-0.11379	0.110096	0.015463	-0.08694	-0.05649	0.026257	-0.0242	0.069931	0.059829	0.038829	0.04941	0.010392	-0.00096	0.096813	-0.00305	0.019053	0.000633	0.019889	[illegible]
59	0.039706	0.043951	-0.10247	0.040091	0.070019	0.069129	-0.06097	0.010311	-0.00909	0.028441	-0.03728	0.035379	0.037734	-0.00675	-0.02723	-0.03555	-0.02913	-0.00024	[illegible]
60	0.126149	-0.10182	-0.0219	0.084224	0.048296	-0.04798	0.0508	-0.06568	-0.05967	-0.05892	-0.01556	-0.04641	-0.04146	-0.02854	0.039067	0.031217	0.03406	-0.01931	[illegible]
61	-0.00024	-0.06912	0.101095	-0.04539	-0.07817	-0.05414	0.098803	0.02634	0.045451	0.015976	0.051408	0.011871	0.008868	0.041734	-0.02444	-0.0086	-0.02797	0.03107	[illegible]
62	-0.12622	0.089945	0.028251	-0.08147	-0.02858	0.064829	-0.06779	0.050987	0.022876	0.04823	-0.03112	0.034926	0.031486	-0.02262	-0.00674	-0.01905	0.007905	-0.02959	[illegible]
63	-0.03925	0.080045	-0.03932	0.030507	0.083548	0.039861	-0.00925	-0.05479	-0.06095	-0.05031	-0.02315	-0.04682	-0.04426	-0.01401	0.038358	0.035546	0.016113	0.015695	[illegible]
64	0.113942	-0.07488	-0.03449	0.0783	0.012859	-0.07542	0.071767	-0.02042	0.018416	-0.00327	0.052141	0.013338	0.018274	0.03979	-0.03738	-0.03122	-0.03208	0.004789	[illegible]
65	0.074902	-0.09414	0.097153	-0.03543	-0.08597	-0.01026	-0.02206	0.066181	0.048473	0.052607	-0.02419	0.083237	0.029721	-0.09477	0.016076	0.008601	0.032011	-0.02326	[illegible]
66	-0.09051	0.037161	0.040894	-0.07482	0.003322	0.078629	-0.06214	-0.01651	-0.05126	-0.03876	-0.03018	-0.04718	-0.04494	0.002827	0.016114	0.019053	-0.01595	0.031974	[illegible]
67	-0.10322	0.104897	-0.0946	0.060126	0.085348	-0.01494	0.04817	-0.05697	-0.01375	-0.02212	0.05159	0.014792	0.026799	0.031301	-0.03739	-0.03555	-0.00809	-0.02727	[illegible]
68	0.058213	-0.03742	-0.04654	0.071041	-0.01938	-0.07414	0.040691	0.0483	0.06057	0.056329	-0.01666	0.032117	0.014813	-0.0412	0.038337	0.031217	0.028081	0.011114	[illegible]
69	0.121432	-0.11194	0.091679	-0.06459	-0.08169	0.037589	-0.06692	0.030017	-0.02729	-0.02262	-0.09646	-0.04749	-0.04345	0.018198	-0.0067	-0.0086	-0.03404	0.009702	[illegible]
70	-0.02022	0.016948	0.052296	-0.06698	0.034761	0.062401	-0.01149	-0.06505	-0.04208	-0.03836	0.049769	0.016232	0.034094	0.017664	-0.02447	-0.01905	0.022985	-0.02645	[illegible]
71	-0.12776	0.115016	-0.08839	0.068797	0.075152	-0.05706	0.071937	0.006279	0.055797	0.053091	-0.00873	0.030964	0.005192	-0.04085	0.039069	0.035546	-0.00044	0.032091	[illegible]
72	-0.01975	0.0053	-0.05785	0.062661	-0.04891	-0.04455	-0.01989	0.061545	0.004284	-0.00881	-0.04184	-0.04776	-0.03987	0.032411	-0.0272	-0.03122	-0.02232	-0.02427	[illegible]
73	0.121579	-0.11402	0.09476	-0.07273	-0.06596	0.070994	-0.06326	-0.04062	-0.0387	-0.05007	0.046722	0.017655	0.039629	0.00112	-0.00909	0.008601	0.033928	0.006259	[illegible]
74	0.057769	-0.02676	0.063174	-0.05809	0.061318	0.022338	0.04749	-0.03888	0.035483	0.043575	-0.00058	0.029781	-0.00468	-0.03378	0.031289	0.019053	-0.02858	0.014876	[illegible]

75	-0.1085	0.108982	-0.08079	0.076382	0.054406	-0.07798	0.042539	0.062914	0.03456	0.015455	-0.04619	-0.04798	-0.03437	0.040293	-0.03829	-0.03555	0.008948	-0.02898	1.256532
76	-0.09017	0.047272	-0.06825	0.058294	-0.07156	0.002061	-0.06605	0.00411	-0.05696	-0.05585	0.042524	0.019062	0.043316	-0.01561	0.01996	0.031217	0.015156	0.031418	0.745032
77	0.075287	-0.10008	0.076504	-0.07973	-0.04094	0.077398	-0.01372	-0.06461	0.005287	0.026907	0.007583	0.028569	-0.01493	-0.02116	0.012688	-0.0086	-0.03168	-0.02067	0.311541
78	0.113726	-0.06611	0.073056	-0.04828	0.079268	-0.02626	0.072097	0.03194	0.055982	0.03289	-0.04941	-0.04815	-0.02721	0.041547	-0.03614	-0.01905	0.032979	0.001251	0.220489
79	-0.03971	0.087642	-0.07191	0.082764	0.026019	-0.06912	-0.01771	0.046785	-0.04281	-0.05503	0.03729	0.020449	0.044916	-0.02977	0.035114	0.035546	-0.01689	0.018696	-0.33908
80	-0.12615	0.082605	-0.07757	0.048086	-0.08416	0.047984	-0.06431	-0.05808	-0.02638	0.010821	0.01556	0.027329	-0.02328	-0.00506	-0.0103	-0.03122	-0.00704	-0.0308	-1.27156
81	0.000238	-0.07209	0.067041	-0.08547	-0.01018	0.054142	0.045764	-0.0144	0.06058	0.046437	-0.05141	-0.04827	-0.01874	0.035967	-0.02149	0.008601	0.027451	0.029971	-1.22765
82	0.126228	-0.09617	0.081785	-0.03772	0.086076	-0.06482	0.044946	0.066079	-0.01473	-0.04771	0.031118	0.021816	0.044352	-0.03909	0.038724	0.019059	-0.03414	-0.01657	-0.80908
83	0.099258	0.053992	-0.0619	0.08764	-0.00602	-0.03986	-0.06511	-0.02247	-0.0507	-0.00854	0.029134	0.026061	-0.03112	0.011879	-0.02973	-0.03555	0.028771	-0.00379	-0.20539
84	-0.11394	0.106397	-0.08567	0.032198	-0.08494	0.075417	-0.01594	-0.05354	0.049079	0.054492	-0.05214	-0.04835	-0.00997	0.024471	0.000594	0.031217	-0.00152	0.022555	0.941568
85	-0.0748	-0.03998	0.056821	-0.08986	0.02201	0.010265	0.072065	0.052948	0.017453	-0.03474	0.024189	0.023161	0.041653	-0.04188	0.028942	-0.0086	-0.02149	-0.03186	1.456096
86	0.090507	-0.11279	0.089225	-0.02655	0.0808	-0.07863	-0.0155	0.02433	-0.0609	-0.0269	0.030178	0.024768	-0.03745	0.02686	-0.03887	-0.01905	0.033762	0.027787	1.232403
87	0.109219	0.01276	-0.05092	0.091531	-0.03722	0.014896	-0.0659	-0.06592	0.029806	0.056105	-0.05159	-0.04838	0.000449	0.008949	0.022472	0.035546	-0.02816	-0.01206	0.469177
88	-0.05621	0.115194	-0.09242	0.020802	-0.07379	0.074149	0.049993	0.012454	0.044774	-0.01766	0.016665	0.024484	0.036947	-0.03783	0.009151	-0.03122	0.009982	-0.00873	-0.33105
89	-0.12148	0.00891	0.046109	-0.09284	0.051108	-0.09759	0.046108	0.058974	-0.05414	-0.04207	0.036459	0.023451	-0.04198	0.037424	-0.03457	0.008601	0.014183	0.025859	-1.32212
90	0.020221	-0.11346	0.086257	-0.01497	0.064176	-0.0624	-0.06411	-0.04536	-0.0081	0.051084	-0.04977	-0.04836	0.010249	-0.00804	0.036579	0.019059	-0.03126	-0.03213	1.60039
91	0.127759	-0.03026	-0.03913	0.098778	-0.06319	0.057056	-0.01814	-0.03366	0.059624	0.001498	0.00873	0.025789	0.030461	-0.02756	-0.01381	-0.03535	0.032714	0.024918	-0.66696
92	0.019751	0.107761	-0.09772	0.009079	-0.05228	0.04465	0.072023	0.064144	-0.0323	-0.05227	0.041842	0.02211	-0.04449	0.041832	-0.01832	0.031217	-0.01782	-0.00725	0.629415
93	-0.12158	0.050547	0.032987	-0.09435	0.078027	-0.07099	-0.01328	-0.00213	-0.03774	0.040029	-0.04672	-0.04829	0.019556	-0.02871	0.038035	-0.0086	-0.00598	-0.01347	1.50294
94	-0.05779	-0.09825	0.099787	-0.00315	0.038538	-0.02294	-0.06623	-0.06296	0.057868	0.020484	0.000581	0.027056	0.022509	-0.01276	-0.03199	-0.01905	0.026794	0.028527	1.698795
95	0.103499	-0.06904	-0.02672	0.094546	-0.08028	0.077983	0.042179	0.037257	-0.00146	-0.05629	0.046194	0.020748	-0.04486	0.039858	0.004271	0.035546	-0.03421	-0.03162	0.553125
96	0.090171	0.085259	-0.10147	-0.00279	-0.02348	-0.00206	0.047925	0.042168	-0.05688	0.024229	-0.04252	-0.04818	0.027921	-0.03548	0.026338	-0.03122	0.024534	0.021435	-1.20512
97	-0.07529	0.085085	0.020844	-0.09437	0.08469	-0.07734	-0.06304	-0.06079	0.039995	0.037048	-0.00758	0.028302	0.013472	0.004138	-0.03911	0.008601	-0.00259	-0.00226	-1.94531
98	-0.11379	-0.06924	0.102744	0.008716	0.007488	0.026257	-0.02032	-0.00825	0.029782	-0.05366	0.04941	0.019365	-0.04307	0.030411	0.025385	0.019059	-0.02064	-0.01787	-1.05915
99	0.039705	-0.09812	-0.01389	0.098824	-0.0861	0.069123	0.071909	0.06339	-0.06017	0.005571	-0.03728	-0.04802	0.034941	-0.04142	0.005531	-0.03535	0.033564	0.030492	0.395307
100	0.126149	0.050771	-0.10862	-0.01461	0.008718	-0.04788	-0.01105	-0.02824	0.010982	0.048231	-0.01556	0.02952	0.003786	0.020358	-0.0327	0.031217	-0.02971	-0.03032	1.275829

APPENDIX D

Platform buoyancy calculation

Weight of structure	= 170 MN
Water depth	= 500 m
Draft	= 30 m
Main column diameter	= 25 m
Pontoons	= 12 m at body, 8 m at tips

Assume axial stiffness per tether to be 100 MN/m

Calculation

$$Length\ of\ pontoons = 55 - \frac{25}{2} = 42.5\ m$$

$$Total\ buoyancy = \left[\left[\left(\frac{\pi}{4}\right) * 25^2 * 30\right] + [3 * 12 * 8 * 42.5]\right] * 1030 * 9.8077$$

$$Total\ buoyancy = 272.382\ MN$$

$$Total\ pretension = 272.382 - 170$$

$$Total\ pretension = 102.382\ MN$$

$$Pretension\ in\ each\ tether = \frac{102.382}{6} = 17.064\ MN$$

$$Elongation\ of\ each\ tether = \frac{17.064}{100} = 0.171\ m$$

$$Water\ plane\ area = \left(\frac{\pi}{4}\right) * 25^2 = 490.874\ m^2$$

$$Change\ in\ buoyancy = \frac{102.382 * 10^6}{1030 * 9.8077} = 10135.617\ m^3$$

$$Change\ in\ draft = \frac{10135.617}{490.874} = 20.684\,m$$

Equivalent diameter of pontoon

$$\frac{\pi D^2}{4} = 12 * 8$$

$$D = 11.056\,m$$

Calculation for surge added mass;

Column: $\left(\frac{\pi}{4}\right) * 25^2 * 30 * 1030 = 15.17\,M\,kg$

2 pontoons: $\left(\frac{\pi}{4}\right) * 53 * 11.056 * 1030 = 5.24\,M\,kg$

1 pontoon: $\left(\frac{\pi}{12}\right) * 11.056^3 * 1030 = 0.36\,M\,kg$

Total: $20.77\,M\,kg$

Actual mass: $\frac{170}{9.8077} = 17.33\,M\,kg$

Total surge mass = $\mathbf{38.1\,M\,kg}$

Calculation for heave added mass;

Column: $\left(\frac{\pi}{4}\right) * 25^3 * 1030 = 4.21\,M\,kg$

3 pontoons: $3 * \left(\frac{\pi}{4}\right) * 11.056^2 * 42.5 * 1030 = 12.61\,M\,kg$

Total: $16.82\,M\,kg$

Actual mass: $\frac{170}{9.8077} = 17.33\,M\,kg$

Total heave mass = $\mathbf{34.15\,M\,kg}$

APPENDIX E

The calculation for surge response constant is shown below;

$$K_{surge} = \frac{Total\ Pretension}{Tether\ Length}$$

$$K_{surge} = \frac{102.382}{(500 - 30)}$$

$$K_{surge} = 0.218\ \frac{M.N}{m}$$

$$\omega_{surge} = \sqrt{\frac{K}{m}}$$

$$\omega_{surge} = \sqrt{\frac{0.218}{38.1}}$$

$$\omega_{surge} = 0.075\ \frac{rad}{s}$$

$$T_{surge} = \frac{2\pi}{\omega}$$

$$T_{surge} = \frac{2\pi}{0.075}$$

$$T_{surge} = 83.1\ s$$

APPENDIX F

Computation of heave response constant is shown below;

Assume tether stiffness= 100 $\frac{M.N}{m}$

$$K_{heave} = (6 * 100) + \frac{490.874 * 1030 * 9.8077}{10^6}$$

$$K_{surge} = 604.958\ \frac{M.N}{m}$$

$$\omega_{heave} = \sqrt{\frac{K}{m}}$$

$$\omega_{heave} = \sqrt{\frac{604.958}{34.15}}$$

$$\omega_{heave} = 4.204\ \frac{rad}{s}$$

$$T_{heave} = \frac{2\pi}{\omega}$$

$$T_{heave} = \frac{2\pi}{4.204}$$

$$T_{heave} = 1.5\ s$$

APPENDIX G

Computation of pitch response constant is shown below;

$$I = 38.1\,M\,kg * r^2$$

$$r^2 = \frac{2}{3} * effective\,radius$$

$$r^2 = \frac{2}{3} * 55\,m$$

$$r^2 = 37\,m$$

$$I = 38.1\,M\,kg * 37\,m$$

$$I = 52158.9\,M\,kg\,m^2$$

$$\omega = \sqrt{\frac{k}{m}} = \frac{2\pi}{T}$$

$$k = \left(\frac{2\pi}{T}\right)^2 m$$

Since T=2s

$$k = \left(\frac{2\pi}{T}\right)^2 * 52158.9\,M\,kg\,m^2$$

$$k = 514787.71\,M\,\frac{kg}{s}\,m^2$$

$$C = 2\xi\sqrt{k * m}$$

Since ξ=0.05

$$C = 2 * 0.05 * \sqrt{514757.71 * 52158.9}$$

$$C = 16{,}386.202$$

APPENDIX H

Calculation for Response Amplitude Operator (RAO)

General Properties

H_{max}, m	6.4
Damping ratio, ξ	0.05

Surge Properties

K(surge), MN/m	0.218
ω (surge), rad/s	0.075
T (surge), s	83.1
Surge mass, M kg	38.1

Heave properties

K(heave), MN/m	604.958
ω (heave), rad/s	4.204
T (heave), s	1.5
Heave mass, M kg	34.15

Pitch properties

K(pitch), MN m	514787.71
ω (heave), rad/s	3.142
T (pitch), s	2
Heave mass, M kg m^2	52 158.9

RAO Surge Calculation

$$S(f) = \frac{\alpha g^2}{(2\pi)^4} f^{-5} \exp\left[-1.25\left(\frac{f}{f_0}\right)^{-4}\right]$$

$$H(f_I) = 2\sqrt{2S(f_I)\Delta f}$$

$$RAO = \frac{\dfrac{F}{\left(\dfrac{H}{2}\right)}}{\sqrt[2]{(K - m\omega^2)^2 + (C\omega)^2}}$$

f	ω	ω/ω₀	s(ω)	s(f)	H(f)	T	Rn	εn	F	H/2	(K-mω²)²	Cω²	RAO	RAO²	s(f) surge
0.005	0.031416	0.047438	0	0	0	200	0.851786	5.351932		0	1413983711	8.1975E-05			
0.015	0.094248	0.142314	0	0	0	66.66667	0.50524	3.174515		0	1.1453E+11	0.00073777			
0.025	0.15708	0.237191	2.5E-168	1.6E-167	1.12E-84	40	0.594272	3.733922	251614	5.59E-85	8.8375E+11	0.00204937	4.78808E+83	2.2926E+167	3.581874974
0.035	0.219911	0.332067	3.42E-42	2.15E-41	1.31E-21	28.57143	0.529193	3.325016	251614	6.55E-22	3.395E+12	0.00401677	2.08443E+20	4.34487E+40	0.932391233
0.045	0.282743	0.426943	1.98E-14	1.24E-13	9.97E-08	22.22222	0.110254	0.692749	251614.1	4.98E-08	9.2773E+12	0.00663997	1657301.617	2.74665E+12	0.341209046
0.055	0.345575	0.52182	7.54E-06	4.73E-05	0.001946	18.18182	0.656512	4.124984	253563.3	0.000973	2.0702E+13	0.00991897	57.26864221	3279.69738	0.155282589
0.065	0.408407	0.616696	0.0121	0.076028	0.077989	15.38462	0.993988	6.245409	350941.4	0.038994	4.0385E+13	0.01385377	1.416191173	2.005597437	0.152481204
0.075	0.471239	0.711572	0.255769	1.607043	0.358557	13.33333	0.805101	5.058598	806944.8	0.179279	7.1584E+13	0.01844437	0.531995383	0.283019088	0.45482384
0.085	0.534071	0.806449	0.933379	5.864591	0.684958	11.76471	0.110718	0.695663	1644091	0.342479	1.181E+14	0.02369076	0.441742718	0.195136629	1.14439658
0.095	0.596903	0.901325	1.546846	9.719123	0.881777	10.52632	0.292958	1.840712	2177157	0.440888	1.8427E+14	0.02959296	0.363772012	0.132330076	1.286132296

0.105	0.659734	0.996201	1.751802	11.00689	0.938377	9.52381	0.316753	1.990221	2454023	0.469189	2.75E+14	0.03615096	0.315404569	0.099480042	1.094966277
0.115	0.722566	1.091078	1.637094	10.28616	0.907135	8.695652	0.891031	5.59851	2802663	0.453567	3.957E+14	0.04336475	0.310633874	0.096493404	0.992547039
0.125	0.785398	1.185954	1.385647	8.706274	0.834567	8	0.510606	3.208234	2963722	0.417283	5.5234E+14	0.05123435	0.302204913	0.09132781	0.795124913
0.135	0.84823	1.28083	1.114931	7.005318	0.748616	7.407407	0.05067	0.318369	3063395	0.374308	7.5146E+14	0.05975975	0.298553281	0.089134062	0.624412433
0.145	0.911062	1.375707	0.875437	5.500532	0.663357	6.896552	0.315493	1.9823	2897925	0.331679	1.0001E+15	0.06894094	0.276279789	0.076330522	0.419858453
0.155	0.973894	1.470583	0.680604	4.276358	0.584901	6.451613	0.155668	0.978092	3122035	0.29245	1.3059E+15	0.07877794	0.295418434	0.087272051	0.373206558
0.165	1.036726	1.565459	0.528221	3.318912	0.51528	6.060606	0.488583	3.06986	3044115	0.25764	1.6769E+15	0.08927073	0.288533079	0.083251337	0.276303879
0.175	1.099557	1.660336	0.411151	2.583341	0.454607	5.714286	0.981559	6.167318	3257561	0.227303	2.1219E+15	0.10041933	0.311118537	0.096794744	0.250053811
0.185	1.162389	1.755212	0.321789	2.021859	0.40218	5.405405	0.902085	5.667968	3206671	0.20109	2.6501E+15	0.11222372	0.309767477	0.09595589	0.194009289
0.195	1.225221	1.850088	0.253581	1.593299	0.357021	5.128205	0.346325	2.176025	3196632	0.17851	3.2712E+15	0.12468391	0.313094242	0.098028004	0.156187892
0.205	1.288053	1.944965	0.201336	1.265033	0.318124	4.878049	0.65387	4.108387	2926245	0.159062	3.9956E+15	0.13779991	0.291039691	0.084704102	0.107153506
0.215	1.350885	2.039841	0.161094	1.012184	0.284561	4.651163	0.829276	5.210496	3123713	0.14228	4.8342E+15	0.1515717	0.315765532	0.099707871	0.100922703
0.225	1.413717	2.134717	0.129889	0.816117	0.255518	4.444444	0.342973	2.154961	3301873	0.127759	5.7983E+15	0.16599929	0.339405807	0.115196302	0.094013712
0.235	1.476549	2.229594	0.105516	0.662979	0.2303	4.255319	0.982628	6.174034	3409711	0.11515	6.8999E+15	0.18108269	0.356477732	0.127076373	0.084248921
0.245	1.53938	2.32447	0.086338	0.542477	0.208322	4.081633	0.362607	2.278325	3421327	0.104161	8.1514E+15	0.19682188	0.363807788	0.132356107	0.07180015
0.255	1.602212	2.419346	0.071135	0.446952	0.189093	3.921569	0.51524	3.237349	3302944	0.094546	9.566E+15	0.21321687	0.357183012	0.127579704	0.05702197
0.265	1.665044	2.514223	0.058995	0.370674	0.172203	3.773585	0.76462	4.80425	3049538	0.086102	1.1157E+16	0.23026766	0.335310093	0.112432859	0.041675917
0.275	1.727876	2.609099	0.049232	0.309335	0.157311	3.636364	0.096885	0.608747	2678794	0.078656	1.2939E+16	0.24797425	0.299405528	0.08964367	0.027729902
0.285	1.790708	2.703975	0.041328	0.259673	0.144131	3.508772	0.396231	2.489593	2318093	0.072066	1.4926E+16	0.26633665	0.263285961	0.069319497	0.018000432
0.295	1.85354	2.798852	0.034888	0.219205	0.132425	3.389831	0.979763	6.156031	2289034	0.066213	1.7134E+16	0.28535484	0.26410915	0.069753643	0.01529034
0.305	1.916372	2.893728	0.029606	0.186023	0.121991	3.278689	0.279335	1.755114	2432460	0.060995	1.9578E+16	0.30502883	0.28501229	0.081232005	0.015110982
0.315	1.979203	2.988604	0.02525	0.158653	0.11266	3.174603	0.958002	6.019306	2863840	0.05633	2.2275E+16	0.32535862	0.340646021	0.116039712	0.018410089
0.325	2.042035	3.08348	0.021637	0.135952	0.104289	3.076923	0.927596	5.828257	2951113	0.052144	2.5241E+16	0.34634421	0.356227143	0.126897777	0.017251977
0.335	2.104867	3.178357	0.018624	0.117021	0.096756	2.985075	0.405375	2.547045	3008031	0.048378	2.8494E+16	0.3679856	0.368350653	0.135682204	0.015877645

RAO Heave Calculation

$$S(f) = \frac{\alpha g^2}{(2\pi)^4} f^{-5} \exp\left[-1.25\left(\frac{f}{f_0}\right)^{-4}\right]$$

$$H(f_l) = 2\sqrt{2S(f_l)\Delta f}$$

$$RAO = \frac{\frac{F}{\left(\frac{H}{2}\right)}}{\sqrt[2]{(K - m\omega^2)^2 + (C\omega)^2}}$$

f	ω	ω/ω_0	s(ω)	s(f)	H(f)	T	Rn	εn	F	H/2	$(K-m\omega^2)^2$	$C\omega^2$	RAO	RAO^2	s(f) heave
0.005	0.031416	0.047438	0	0	0	200	0.851786	5.351932		0	1095592856	0.203899			
0.015	0.094248	0.142314	0	0	0	66.66667	0.50524	3.174515		0	9.165E+10	1.835093			
0.025	0.15708	0.237191	2.5E-168	1.6E-167	1.12E-84	40	0.594272	3.733922	2.31E-80	5.59E-85	7.0899E+11	5.097482	0.048992757	0.00240029	3.7502E-170
0.035	0.219911	0.332067	3.42E-42	2.15E-41	1.31E-21	28.57143	0.529193	3.325016	7.55E-18	6.55E-22	2.7256E+12	9.991064	0.00698445	4.87825E-05	1.04685E-45
0.045	0.282743	0.426943	1.98E-14	1.24E-13	9.97E-08	22.22222	0.110254	0.692749	0.00102	4.98E-08	7.45E+12	16.51584	0.0074984	5.6226E-05	6.98481E-18
0.055	0.345575	0.52182	7.54E-06	4.73E-05	0.001946	18.18182	0.656512	4.124984	31.02212	0.000973	1.6627E+13	24.67181	0.007818088	6.11225E-05	2.89394E-09
0.065	0.408407	0.616696	0.0121	0.076028	0.077989	15.38462	0.993988	6.245409	1816.867	0.038994	3.2439E+13	34.45898	0.008180708	6.6924E-05	5.08808E-06
0.075	0.471239	0.711572	0.255769	1.607043	0.358557	13.33333	0.805101	5.058598	11170.29	0.179279	5.7501E+13	45.87734	0.008216702	6.75142E-05	0.000108498
0.085	0.534071	0.806449	0.933379	5.864591	0.684958	11.76471	0.110718	0.695663	29611.28	0.342479	9.4869E+13	58.92689	0.008876912	7.87996E-05	0.000462127
0.095	0.596903	0.901325	1.546846	9.719123	0.881777	10.52632	0.292958	1.840712	40488.22	0.440888	1.4803E+14	73.60764	0.007547865	5.69703E-05	0.000553701

0.105	0.659734	0.996201	1.751802	11.00689	0.938377	9.52381	0.316753	1.990221	48726.49	0.469189	2.2091E+14	89.91958	0.006987252	4.88217E-05	0.000537375
0.115	0.722566	1.091078	1.637094	10.28616	0.907135	8.695652	0.891031	5.59851	56966.87	0.453567	3.1788E+14	107.8627	0.007044485	4.96248E-05	0.000510448
0.125	0.785398	1.185954	1.385647	8.706274	0.834567	8	0.510606	3.208234	55202.15	0.417283	4.4373E+14	127.437	0.006280104	3.94397E-05	0.000343373
0.135	0.84823	1.28083	1.114931	7.005318	0.748616	7.407407	0.05067	0.318369	57188.42	0.374308	6.0369E+14	148.6426	0.006218303	3.86673E-05	0.000270877
0.145	0.911062	1.375707	0.875437	5.500532	0.663357	6.896552	0.315493	1.9823	57830.55	0.331679	8.0344E+14	171.4793	0.006151242	3.78378E-05	0.000208128
0.155	0.973894	1.470583	0.680604	4.276358	0.584901	6.451613	0.155668	0.978092	56298.17	0.29245	1.0491E+15	195.9472	0.005943421	3.53243E-05	0.000151059
0.165	1.036726	1.565459	0.528221	3.318912	0.51528	6.060606	0.488583	3.06986	52045.1	0.25764	1.3472E+15	222.0463	0.005503713	3.02909E-05	0.000100533
0.175	1.099557	1.660336	0.411151	2.583341	0.454607	5.714286	0.981559	6.167318	51552.1	0.227303	1.7047E+15	249.7766	0.005493136	3.01745E-05	7.79511E-05
0.185	1.162389	1.755212	0.321789	2.021859	0.40218	5.405405	0.902085	5.667968	49214.86	0.20109	2.129E+15	279.1381	0.005304172	2.81342E-05	5.68835E-05
0.195	1.225221	1.850088	0.253581	1.593299	0.357021	5.128205	0.346325	2.176025	48369.42	0.17851	2.628E+15	310.1308	0.005285582	2.79374E-05	4.45126E-05
0.205	1.288053	1.944965	0.201336	1.265033	0.318124	4.878049	0.65387	4.108387	48860.07	0.159062	3.21E+15	342.7547	0.005421689	2.93947E-05	3.71853E-05
0.215	1.350885	2.039841	0.161094	1.012184	0.284561	4.651163	0.829276	5.210496	44981.98	0.14228	3.8837E+15	377.0098	0.005073068	2.5736E-05	2.60496E-05
0.225	1.413717	2.134717	0.129889	0.816117	0.255518	4.444444	0.342973	2.154961	40874.44	0.127759	4.6583E+15	412.896	0.004687581	2.19734E-05	1.79329E-05
0.235	1.476549	2.229594	0.105516	0.662979	0.2303	4.255319	0.982628	6.174034	36482.48	0.11515	5.5433E+15	450.4135	0.004255366	1.81081E-05	1.20053E-05
0.245	1.53938	2.32447	0.086338	0.542477	0.208322	4.081633	0.362607	2.278325	31762.69	0.104161	6.5488E+15	489.5622	0.003768185	1.41992E-05	7.70275E-06
0.255	1.602212	2.419346	0.071135	0.446952	0.189093	3.921569	0.51524	3.237349	26695.28	0.094546	7.6852E+15	530.342	0.003220782	1.03734E-05	4.63643E-06
0.265	1.665044	2.514223	0.058995	0.370674	0.172203	3.773585	0.76462	4.80425	22945.4	0.086102	8.9635E+15	572.7531	0.002814785	7.92302E-06	2.93685E-06
0.275	1.727876	2.609099	0.049232	0.309335	0.157311	3.636364	0.096885	0.608747	21519.57	0.078656	1.0395E+16	616.7953	0.002683434	7.20082E-06	2.22746E-06
0.285	1.790708	2.703975	0.041328	0.259673	0.144131	3.508772	0.396231	2.489593	20474.68	0.072066	1.1992E+16	662.4687	0.002594482	6.73134E-06	1.74795E-06
0.295	1.85354	2.798852	0.034888	0.219205	0.132425	3.389831	0.979763	6.156031	19425.23	0.066213	1.3765E+16	709.7734	0.002500541	6.2527E-06	1.37062E-06
0.305	1.916372	2.893728	0.029606	0.186023	0.121991	3.278689	0.279335	1.755114	18363.25	0.060995	1.5729E+16	758.7092	0.002400511	5.76245E-06	1.07195E-06
0.315	1.979203	2.988604	0.02525	0.158653	0.11266	3.174603	0.958002	6.019306	17472.56	0.05633	1.7895E+16	809.2762	0.002318715	5.37644E-06	8.5299E-07
0.325	2.042035	3.08348	0.021637	0.135952	0.104289	3.076923	0.927596	5.828257	16207.46	0.052144	2.0278E+16	861.4744	0.00218269	4.76414E-06	6.47693E-07
0.335	2.104867	3.178357	0.018624	0.117021	0.096756	2.985075	0.405375	2.547045	14913.64	0.048378	2.2892E+16	915.3038	0.002037506	4.15143E-06	4.85804E-07

RAO Pitch Calculation

$$S(f) = \frac{\alpha g^2}{(2\pi)^4} f^{-5} \exp\left[-1.25\left(\frac{f}{f_0}\right)^{-4}\right]$$

$$H(f_l) = 2\sqrt{2S(f_l)\Delta f}$$

$$RAO = \frac{\frac{F}{\left(\frac{H}{2}\right)}}{\sqrt[2]{(K - m\omega^2)^2 + (C\omega)^2}}$$

f	ω	ω/ω₀	s(ω)	s(f)	H(f)	T	Rn	εn	F	H/2	(K-mω²)²	Cω²	RAO	RAO²	s(f) pitch
0.005	0.031416	0.047438	0	0	0	200	0.851786	5.351932		0	2.5973E+15	265006.395			
0.015	0.094248	0.142314	0	0	0	66.66667	0.50524	3.174515		0	2.1418E+17	2385057.55			
0.025	0.15708	0.237191	2.5E-168	1.6E-167	1.12E-84	40	0.594272	3.733922	5687182	5.59E-85	1.655E+18	6625159.87	7.9085E+81	6.2544E+163	0.000977182
0.035	0.219911	0.332067	3.42E-42	2.15E-41	1.31E-21	28.57143	0.529193	3.325016	5687182	6.55E-22	6.3602E+18	12985313.3	3.4422E+18	1.18487E+37	0.000254269
0.045	0.282743	0.426943	1.98E-14	1.24E-13	9.97E-08	22.22222	0.110254	0.692749	5687184	4.98E-08	1.7383E+19	21465518	27366.16728	748907111.8	9.30348E-05
0.055	0.345575	0.52182	7.54E-06	4.73E-05	0.001946	18.18182	0.656512	4.124984	491854.3	0.000973	3.8793E+19	32065773.8	0.081152024	0.006585651	3.11808E-07
0.065	0.408407	0.616696	0.0121	0.076028	0.077989	15.38462	0.993988	6.245409	7972481	0.038994	7.568E+19	44786080.7	0.023501905	0.00055234	4.19932E-05
0.075	0.471239	0.711572	0.255769	1.607043	0.358557	13.33333	0.805101	5.058598	18541713	0.179279	1.3415E+20	59626438.8	0.008929553	7.97369E-05	0.000128141
0.085	0.534071	0.806449	0.933379	5.864591	0.684958	11.76471	0.110718	0.695663	36411639	0.342479	2.2132E+20	76586848.1	0.007146533	5.10729E-05	0.000299522
0.095	0.596903	0.901325	1.546846	9.719123	0.881777	10.52632	0.292958	1.840712	48962341	0.440888	3.4534E+20	95667308.5	0.005975996	3.57125E-05	0.000347094

0.105	0.659734	0.996201	1.751802	11.00689	0.938377	9.52381	0.316753	1.990221	53687788	0.469189	5.1536E+20	116867820	0.005040472	2.54064E-05	0.000279645
0.115	0.722566	1.091078	1.637094	10.28616	0.907135	8.695652	0.891031	5.59851	62341600	0.453567	7.4157E+20	140188383	0.005047317	2.54754E-05	0.000262044
0.125	0.785398	1.185954	1.385647	8.706274	0.834567	8	0.510606	3.208234	60705709	0.417283	1.0351E+21	165628997	0.004521652	2.04453E-05	0.000178003
0.135	0.84823	1.28083	1.114931	7.005318	0.748616	7.407407	0.05067	0.318369	63145655	0.374308	1.4083E+21	193189662	0.004495363	2.02083E-05	0.000141566
0.145	0.911062	1.375707	0.875437	5.500532	0.663357	6.896552	0.315493	1.9823	60278757	0.331679	1.8743E+21	222870378	0.00419786	1.7622E-05	9.69305E-05
0.155	0.973894	1.470583	0.680604	4.276358	0.584901	6.451613	0.155668	0.978092	59988689	0.29245	2.4473E+21	254671145	0.004146391	1.71926E-05	7.35216E-05
0.165	1.036726	1.565459	0.528221	3.318912	0.51528	6.060606	0.488583	3.06986	61196083	0.25764	3.1427E+21	288591964	0.004237002	1.79522E-05	5.95817E-05
0.175	1.099557	1.660336	0.411151	2.583341	0.454607	5.714286	0.981559	6.167318	54699753	0.227303	3.9767E+21	324632834	0.003816092	1.45626E-05	3.762E-05
0.185	1.162389	1.755212	0.321789	2.021859	0.40218	5.405405	0.902085	5.667968	53349219	0.20109	4.9666E+21	362793755	0.003764516	1.41716E-05	2.86529E-05
0.195	1.225221	1.850088	0.253581	1.593299	0.357021	5.128205	0.346325	2.176025	54744802	0.17851	6.1307E+21	403074727	0.00391674	1.53409E-05	2.44426E-05
0.205	1.288053	1.944965	0.201336	1.265033	0.318124	4.878049	0.65387	4.108387	54124951	0.159062	7.4884E+21	445475750	0.003932224	1.54624E-05	1.95604E-05
0.215	1.350885	2.039841	0.161094	1.012184	0.284561	4.651163	0.829276	5.210496	47501916	0.14228	9.0599E+21	489996824	0.003507548	1.23029E-05	1.24528E-05
0.225	1.413717	2.134717	0.129889	0.816117	0.255518	4.444444	0.342973	2.154961	42001256	0.127759	1.0867E+22	536637950	0.003153696	9.9458E-06	8.11694E-06
0.235	1.476549	2.229594	0.105516	0.662979	0.2303	4.255319	0.982628	6.174034	44278957	0.11515	1.2931E+22	585399126	0.00338151	1.14346E-05	7.5809E-06
0.245	1.53938	2.32447	0.086338	0.542477	0.208322	4.081633	0.362607	2.278325	45231658	0.104161	1.5277E+22	636280354	0.003513325	1.23435E-05	6.69604E-06
0.255	1.602212	2.419346	0.071135	0.446952	0.189093	3.921569	0.51524	3.237349	44516208	0.094546	1.7928E+22	689281633	0.003516463	1.23655E-05	5.52679E-06
0.265	1.665044	2.514223	0.058995	0.370674	0.172203	3.773585	0.76462	4.80425	41702597	0.086102	2.091E+22	744402963	0.003349452	1.12188E-05	4.15853E-06
0.275	1.727876	2.609099	0.049232	0.309335	0.157311	3.636364	0.096885	0.608747	37988466	0.078656	2.425E+22	801644344	0.003101489	9.61924E-06	2.97556E-06
0.285	1.790708	2.703975	0.041328	0.259673	0.144131	3.508772	0.396231	2.489593	33962542	0.072066	2.7974E+22	861005777	0.002817701	7.93944E-06	2.06166E-06
0.295	1.85354	2.798852	0.034888	0.219205	0.132425	3.389831	0.979763	6.156031	29676907	0.066213	3.2112E+22	922487260	0.002501195	6.25598E-06	1.37134E-06
0.305	1.916372	2.893728	0.029606	0.186023	0.121991	3.278689	0.279335	1.755114	25155491	0.060995	3.6692E+22	986088795	0.002153022	4.6355E-06	8.62308E-07
0.315	1.979203	2.988604	0.02525	0.158653	0.11266	3.174603	0.958002	6.019306	24520151	0.05633	4.1746E+22	1051810381	0.00213047	4.5389E-06	7.20112E-07
0.325	2.042035	3.08348	0.021637	0.135952	0.104289	3.076923	0.927596	5.828257	25476824	0.052144	4.7305E+22	1119652018	0.002246384	5.04624E-06	6.86045E-07
0.335	2.104867	3.178357	0.018624	0.117021	0.096756	2.985075	0.405375	2.547045	26024396	0.048378	5.3402E+22	1189613706	0.002327862	5.41894E-06	6.34129E-07
0.345	2.167699	3.273233	0.016099	0.101154	0.089957	2.898551	0.974649	6.1239		0.044979	6.0069E+22	1261695446			
0.355	2.230531	3.368109	0.013972	0.08779	0.083805	2.816901	0.45019	2.828627		0.041902	6.7342E+22	1335897236			

0.365	2.293363	3.462986	0.012173	0.076484	0.078222	2.739726	0.519203	3.26225		0.039111	7.5257E+22	1412219078			
0.375	2.356194	3.557862	0.010643	0.066875	0.073144	2.666667	0.997038	6.264577		0.036572	8.3849E+22	1490660971			
0.385	2.419026	3.652738	0.009338	0.058675	0.068513	2.597403	0.240035	1.508181		0.034256	9.3157E+22	1571222915			
0.395	2.481858	3.747615	0.00822	0.05165	0.064281	2.531646	0.41511	2.608211		0.03214	1.0322E+23	1653904910			

APPENDIX I

Surge Time Series

$$\eta(x,t) = \sum\left(\frac{H(n)}{2}\right)\cos[k(n)x - 2\pi f(n)t + \varepsilon(n)]$$

t	η18	η19	η20	η21	η22	η23	η24	η25	η26	η27	η28	η29	η30	η31	η32	η33	η34	η
0	0.0393	0.038619	0.052572	0.036745	0.030344	0.040837	0.022775	0.035431	0.029386	0.020834	0.023439	0.017504	0.009744	0.016711	0.011036	0.011141	0.016376	2.007734
1	0.070227	0.060193	0.035658	0.037292	0.038953	0.020791	0.036142	0.014548	0.015709	0.017937	-0.00142	0.003328	0.011226	-0.00115	0.010023	0.008186	-0.00229	1.985495
2	0.024464	0.009192	-0.02841	-0.01594	-0.01335	-0.03433	-0.01597	-0.03452	-0.03037	-0.02421	-0.023	-0.01896	-0.01601	-0.01593	-0.019	-0.01857	-0.01405	0.808224
3	-0.04801	-0.05289	-0.05491	-0.04618	-0.04478	-0.03153	-0.03915	-0.01672	-0.0138	-0.01338	0.008612	0.004942	-0.00229	0.011944	0.005067	0.008678	0.016588	0.052182
4	-0.06806	-0.0512	-0.00878	-0.00983	-0.00619	0.024466	0.008604	0.033466	0.03124	0.026729	0.020302	0.0168	0.017288	0.00784	0.014973	0.010693	-0.00284	0.11644
5	-0.01378	0.012221	0.048957	0.040697	0.042078	0.039187	0.040768	0.018819	0.011838	0.008349	-0.01496	-0.01227	-0.00735	-0.01725	-0.01696	-0.01839	-0.0137	-0.1616
6	0.055545	0.06091	0.041952	0.032542	0.024544	-0.01221	-0.00093	-0.03228	-0.03198	-0.0283	-0.01562	-0.01145	-0.01319	0.00385	-0.0015	0.006002	0.016785	-0.01187
7	0.064217	0.03616	-0.02054	-0.02254	-0.03137	-0.04301	-0.04094	-0.02085	-0.00983	-0.00302	0.01985	0.017265	0.01471	0.014646	0.018153	0.012938	-0.00339	0.171077
8	0.002763	-0.03219	-0.05586	-0.04512	-0.03823	-0.00125	-0.00678	0.030975	0.032601	0.028869	0.00941	0.003913	0.004977	-0.01377	-0.01292	-0.01775	-0.01333	0.17868
9	-0.06171	-0.06173	-0.01731	-0.00264	0.014691	0.042615	0.039668	0.022793	0.007781	-0.00241	-0.02279	-0.01897	-0.01749	-0.00532	-0.00789	0.003179	0.016964	0.191233
10	-0.05879	-0.01684	0.044137	0.043648	0.04464	0.014582	0.014241	-0.02954	-0.03309	-0.02842	-0.00228	0.004364	0.00478	0.017374	0.019186	0.014864	-0.00394	0.20327
11	0.008325	0.048351	0.047212	0.02699	0.004785	-0.03805	-0.03699	-0.02465	-0.0057	0.007759	0.023507	0.017068	0.01482	-0.00645	-0.00735	-0.01667	-0.01295	0.134176
12	0.066352	0.055246	-0.01215	-0.02859	-0.04255	-0.02649	-0.0212	0.027994	0.033448	0.026955	-0.00508	-0.01181	-0.01305	-0.013	-0.01335	0.000276	0.017127	0.091302
13	0.051921	-0.00447	-0.05544	-0.04294	-0.02335	0.029766	0.032997	0.026407	0.003601	-0.01283	-0.02192	-0.01192	-0.00754	0.015263	0.017951	0.016423	-0.00448	-0.01347
14	-0.01921	-0.0588	-0.02541	0.004627	0.032365	0.0358	0.027414	-0.02634	-0.03367	-0.02454	0.011934	0.017009	0.017256	0.002661	-0.00091	-0.01519	-0.01256	-0.25358
15	-0.06936	-0.04223	0.038229	0.045523	0.03747	-0.01856	-0.02784	-0.02806	-0.00149	0.017451	0.018185	0.004495	-0.00209	-0.01707	-0.01723	-0.00263	0.017274	-0.43084

16	-0.04377	0.025251	0.05131	0.020774	-0.01602	-0.04161	-0.03265	0.024572	0.033768	0.021255	-0.01762	-0.01897	-0.01609	0.0089	0.014593	0.017579	-0.00502	-0.46522
17	0.029619	0.062289	-0.00347	-0.03393	-0.04446	0.005547	0.021691	0.029605	-0.00064	-0.02145	-0.01267	0.003782	0.011068	0.011036	0.005639	-0.01333	-0.01216	-0.39389
18	0.070664	0.024225	-0.05366	-0.03971	-0.00338	0.043344	0.036736	-0.02271	-0.03373	-0.01722	0.021588	0.01732	0.009914	-0.01638	-0.01907	-0.00548	0.017403	-0.21426
19	0.034543	-0.04305	-0.03289	0.011775	0.042984	0.008014	-0.01478	-0.03103	0.002755	0.024692	0.005917	-0.01134	-0.0166	5.93E-05	0.00951	0.018301	-0.00556	-0.05515
20	-0.0393	-0.05842	0.03138	0.046278	0.022133	-0.04084	-0.03952	0.020763	0.033555	0.01257	-0.02344	-0.01237	-0.00065	0.016337	0.011518	-0.01114	-0.01174	-0.0352
21	-0.07023	-0.00335	0.054145	0.014047	-0.03333	-0.02079	0.007339	0.032337	-0.00486	-0.02706	0.001417	0.016737	0.016963	-0.01113	-0.01866	-0.00819	0.017514	-0.09952
22	-0.02446	0.055753	0.005301	-0.03844	-0.03667	0.034332	0.040898	-0.01873	-0.03325	-0.00748	0.022996	0.005071	-0.00881	-0.0088	0.003303	0.018573	-0.00609	-0.18511
23	0.048013	0.047638	-0.05055	-0.0355	0.017328	0.031532	0.000359	-0.03351	0.006951	0.028466	-0.00861	-0.01895	-0.01205	0.017088	0.016036	-0.00868	-0.01132	-0.23946
24	0.06806	-0.01791	-0.03955	0.018634	0.044233	-0.02447	-0.04083	0.016626	0.032813	0.002119	-0.0203	0.003196	0.015534	-0.00278	-0.01604	-0.01069	0.017609	-0.235
25	0.013783	-0.06187	0.023759	0.045893	0.001971	-0.03919	-0.00804	0.034558	-0.00901	-0.02886	0.014963	0.017555	0.003378	-0.01521	-0.0033	0.018388	-0.00661	-0.24244
26	-0.05554	-0.03123	0.055646	0.006974	-0.04337	0.012206	0.039317	-0.01446	-0.03225	0.003314	0.01562	-0.01086	-0.01742	0.013079	0.018658	-0.006	-0.01088	-0.27063
27	-0.06422	0.037065	0.01394	-0.042	-0.02089	0.043006	0.015444	-0.03547	0.011039	0.028241	-0.01985	-0.01282	0.006342	0.006345	-0.01152	-0.01294	0.017686	-0.24036
28	-0.00276	0.060667	-0.0462	-0.03041	0.034257	0.001249	-0.03641	0.012227	0.031553	-0.00863	-0.00941	0.016448	0.01388	-0.01738	-0.0095	0.01775	-0.00713	-0.15592
29	0.061708	0.011122	-0.04524	0.025034	0.03584	-0.04262	-0.0223	0.036234	-0.01302	-0.02662	0.022795	0.005643	-0.01409	0.005428	0.019073	-0.00318	-0.01043	-0.07375
30	0.058793	-0.05183	0.015553	0.044379	-0.01862	-0.01458	0.032214	-0.00995	-0.03073	0.013639	0.002278	-0.01891	-0.00602	0.0137	-0.00565	-0.01486	0.017746	-0.01769
31	-0.00833	-0.05229	0.055778	-0.00027	-0.04396	0.038053	0.02836	-0.03686	0.014952	0.02405	-0.02351	0.002607	0.017446	-0.01471	-0.01459	0.016674	-0.00764	0.000147
32	-0.06635	0.010296	0.022235	-0.04453	-0.00056	0.028488	-0.02688	0.007635	0.029796	-0.01817	0.005077	0.017773	-0.00371	-0.00373	0.017233	-0.00028	-0.00997	-0.03089
33	-0.05192	0.060471	-0.04071	-0.02458	0.04372	-0.02977	-0.03342	0.037339	-0.01682	-0.02063	0.021919	-0.01036	-0.01537	0.01724	0.0009	-0.01642	0.017788	0.0705
34	0.019209	0.037735	-0.04982	0.030817	0.019634	-0.0358	0.020586	-0.00529	-0.02874	0.022048	-0.01193	-0.01325	0.012293	-0.00795	-0.01795	0.015188	-0.00814	0.006979
35	0.069362	-0.0305	0.006963	0.041771	-0.03515	0.018565	0.037293	-0.03767	0.018629	0.016481	-0.01819	0.016143	0.008514	-0.01186	0.013356	0.002632	-0.0095	0.192731
36	0.043771	-0.06196	0.054535	-0.00751	-0.03497	0.041609	-0.01357	0.002923	0.027568	-0.02515	0.017624	0.006209	-0.01704	0.015978	0.00734	-0.01758	0.017813	0.244525
37	-0.02962	-0.01872	0.029983	-0.04596	0.019896	-0.00555	-0.03985	0.037855	-0.02036	-0.01175	0.012671	-0.01885	0.000996	0.001032	-0.01919	0.013329	-0.00863	0.14007
38	-0.07066	0.047093	-0.03422	-0.01814	0.043652	-0.04334	0.006067	-0.00055	-0.02629	0.027361	-0.02159	0.002015	0.016488	-0.01668	0.0079	0.005477	-0.00902	0.130459
39	-0.03454	0.056122	-0.05317	0.035842	-0.00085	-0.00801	0.040988	-0.03789	0.022012	0.006597	-0.00592	0.017973	-0.0102	0.010266	0.012912	-0.0183	0.01782	0.185465
40	0.0393	-0.00252	-0.0018	0.038135	-0.04402	0.040837	0.001648	-0.00184	0.024907	-0.0286	0.023439	-0.00986	-0.0108	0.009722	-0.01816	0.011141	-0.00912	0.13784
41	0.070227	-0.05812	0.05195	-0.01456	-0.01836	0.020791	-0.04068	0.037774	-0.02358	-0.00121	-0.00142	-0.01367	0.016221	-0.01685	0.001509	0.008186	-0.00854	0.105085

42	0.024464	-0.04365	0.036993	-0.04626	0.036015	-0.03433	-0.0093	0.004208	-0.02343	0.028831	-0.023	0.015822	0.001748	0.001695	0.016957	-0.01857	0.017809	0.167958
43	-0.04801	0.02345	-0.02689	-0.01125	0.034068	-0.03153	0.038927	-0.03751	0.025048	-0.00421	0.008612	0.006769	-0.0172	0.015705	-0.01498	0.008678	-0.00959	0.228966
44	-0.06806	0.062275	-0.05521	0.039984	-0.02115	0.024466	0.016631	-0.00656	0.021852	-0.02804	0.020302	-0.01878	0.007847	-0.01233	-0.00506	0.010693	-0.00804	0.275847
45	-0.01378	0.026015	-0.01051	0.03356	-0.0433	0.039187	-0.0358	0.037097	-0.02642	0.00949	-0.01496	0.001422	0.012818	-0.00735	0.018997	-0.01839	0.017781	0.279362
46	0.055545	-0.04161	0.048086	-0.02126	0.002262	-0.01221	-0.02337	0.008895	-0.02019	0.026252	-0.01562	0.018155	-0.015	0.017313	-0.01003	0.006002	-0.01006	0.20085
47	0.064217	-0.05907	0.043091	-0.04542	0.044283	-0.04301	0.031399	-0.03654	0.02769	-0.01443	0.01985	-0.00934	-0.00445	-0.00438	-0.01103	0.012938	-0.00754	0.151423
48	0.002763	-0.00531	-0.01889	-0.00409	0.017058	-0.00125	0.029278	-0.01119	0.018452	-0.02354	0.00941	-0.01408	0.017482	-0.01434	0.018791	-0.01775	0.017736	0.145754
49	-0.06171	0.054853	-0.05589	0.043142	-0.03684	0.042615	-0.02589	0.035835	-0.02885	0.018861	-0.02279	0.015485	-0.00531	0.014099	-0.00389	0.003179	-0.01052	0.078416
50	-0.05879	0.048875	-0.01897	0.028158	-0.03313	0.014582	-0.03415	0.013442	-0.01664	0.019986	-0.00228	0.007323	-0.01452	0.004793	-0.0157	0.014864	-0.00703	-0.00284
51	0.008325	-0.01603	0.043038	-0.02743	0.022386	-0.03805	0.01946	-0.03499	0.029894	-0.02262	0.023507	-0.01868	0.013409	-0.01735	0.016363	-0.01667	0.017673	-0.02684
52	0.066352	-0.06161	0.048129	-0.04346	0.042898	-0.02649	0.037813	-0.01564	0.014762	-0.01573	-0.00508	0.000827	0.007039	0.006959	0.0027	0.000276	-0.01096	-0.02967
53	0.051921	-0.0329	-0.01043	0.003178	-0.00367	0.029766	-0.01234	0.034008	-0.03082	0.025583	-0.02192	0.018319	-0.01734	0.012632	-0.01851	0.016423	-0.00651	-0.02829
54	-0.01921	0.035474	-0.0552	0.045237	-0.0445	0.0358	-0.04014	0.017776	-0.01283	0.010913	0.011934	-0.00882	0.002634	-0.01552	0.012	-0.01519	0.017592	-0.02235
55	-0.06936	0.061081	-0.02696	0.022064	-0.01574	-0.01856	0.004789	-0.03289	0.031627	-0.02764	0.018185	-0.01447	0.015866	-0.00212	0.008976	-0.00263	-0.0114	0.007819
56	-0.04377	0.013042	0.03693	-0.03293	0.03763	-0.04161	0.041038	-0.01984	0.010839	-0.00571	-0.01762	0.015133	-0.01149	0.016953	-0.01913	0.017579	-0.00599	0.076039
57	0.029619	-0.05072	0.051981	-0.04044	0.032162	0.005547	0.002935	0.031645	-0.03231	0.028712	-0.01267	0.007869	-0.00946	-0.00937	0.006219	-0.01333	0.017494	0.085356
58	0.070664	-0.05333	-0.00171	0.010363	-0.0236	0.043344	-0.04049	0.021831	-0.00881	0.000307	0.021588	-0.01857	0.016764	-0.01061	0.01419	-0.00548	-0.01183	-0.01808
59	0.034543	0.008362	-0.05314	0.046218	-0.04246	0.008014	-0.01056	-0.03027	0.032862	-0.02877	0.005917	0.000231	0.000103	0.016552	-0.01749	0.018301	-0.00546	-0.13875
60	-0.0393	0.059971	-0.03429	0.015426	0.005075	-0.04084	0.038499	-0.02373	0.006745	0.005108	-0.02344	0.018465	-0.01682	-0.00061	-0.0003	-0.01114	0.017379	-0.19773
61	-0.07023	0.039273	0.029912	-0.03761	0.044672	-0.02079	0.017801	0.028783	-0.03329	0.027808	0.001417	-0.00829	0.009283	-0.01614	0.017727	-0.00819	-0.01224	-0.18797
62	-0.02446	-0.02878	0.054554	-0.03641	0.014415	0.034332	-0.03515	0.025541	-0.00465	-0.01034	0.022996	-0.01485	0.011641	0.011541	-0.01378	0.018573	-0.00492	-0.17984
63	0.048013	-0.06213	0.007047	0.017294	-0.03838	0.031532	-0.02442	-0.02718	0.033578	-0.02586	-0.00861	0.014766	-0.01578	0.008323	-0.00678	-0.00868	0.017247	-0.22403
64	0.06806	-0.02057	-0.04978	0.046062	-0.03116	-0.02447	0.030553	-0.02725	0.002544	0.01521	-0.0203	0.008407	-0.00284	-0.01718	0.019167	-0.01069	-0.01264	-0.18219
65	0.013783	0.045789	-0.04077	0.008408	0.024788	-0.03919	0.030167	0.025466	-0.03374	0.022999	0.014963	-0.01843	0.017362	0.003316	-0.00844	0.018388	-0.00438	-0.05163
66	-0.05554	0.056944	0.022158	-0.04137	0.041975	0.012206	-0.02487	0.028848	-0.00042	-0.01954	0.01562	-0.00037	-0.00685	0.014933	-0.01246	-0.006	0.017097	-0.0971
67	-0.06422	-0.00056	0.055783	-0.03149	-0.00647	0.043006	-0.03485	-0.02365	0.033764	-0.01932	-0.01985	0.018593	-0.01354	-0.01343	0.018341	-0.01294	-0.01303	-0.26921

68	-0.00276	-0.05739	0.015633	0.023798	-0.0448	0.001249	0.018315	-0.03033	-0.0017	0.023175	-0.00941	-0.00775	0.014405	-0.00583	-0.00211	0.01775	-0.00383	-0.29353
69	0.061708	-0.04502	-0.04519	0.044771	-0.01307	-0.04262	0.038296	0.021749	-0.03366	0.01496	0.022795	-0.01521	0.005501	0.017384	-0.01667	-0.00318	0.016931	-0.27908
70	0.058793	0.021626	-0.04625	0.001183	0.039097	-0.01458	-0.01111	0.0317	0.003811	-0.02599	0.002278	0.014384	-0.01748	-0.00594	0.015347	-0.01486	-0.0134	-0.16506
71	-0.00883	0.062201	0.013859	-0.04411	0.030129	0.038053	-0.04039	-0.01976	0.033418	-0.01007	-0.02351	0.008938	0.004249	-0.01336	0.004476	0.016674	-0.00329	0.05106
72	-0.06635	0.02778	0.055639	-0.0258	-0.02595	0.026488	0.003506	-0.03294	-0.00591	0.027886	0.005077	-0.01828	0.015104	0.014994	-0.0189	-0.00028	0.016748	-0.01845
73	-0.05192	-0.04014	0.023835	0.029717	-0.04145	-0.02977	0.041047	0.017688	-0.03305	0.004819	0.021919	-0.00096	-0.01268	0.003199	0.010538	-0.01642	-0.01376	-0.10466
74	0.019209	-0.05966	-0.03949	0.042377	0.007868	-0.0358	0.00422	0.034052	0.007986	-0.02879	-0.01193	0.018703	-0.00803	-0.01716	0.010532	0.015188	-0.00273	-0.1468
75	0.069362	-0.00725	-0.05059	-0.00607	0.044884	0.018565	-0.04025	-0.01555	0.032545	0.0006	-0.01819	-0.0072	0.017158	0.008427	-0.0189	0.002632	0.016549	-0.1655
76	0.043771	0.053899	0.005218	-0.04577	0.011714	0.041609	-0.0118	-0.03503	-0.01003	0.02868	0.017624	-0.01556	-0.00154	0.011452	0.004483	-0.01758	-0.01411	-0.19507
77	-0.02962	0.050064	0.054124	-0.01946	-0.03977	-0.00555	0.038032	0.013348	-0.03192	-0.006	0.012671	0.013988	-0.0163	-0.01619	0.015343	0.013329	-0.00218	-0.16886
78	-0.07066	-0.01413	0.03145	0.034904	-0.02907	-0.04334	0.018954	0.035868	0.012036	-0.02755	-0.02159	0.009459	0.010637	-0.00049	-0.01667	0.005477	0.016333	-0.13538
79	-0.03454	-0.06129	-0.03282	0.038941	0.027092	-0.00801	-0.03446	-0.01109	0.031159	0.011183	-0.00592	-0.01812	0.010362	0.016515	-0.0021	-0.0183	-0.01445	-0.04495
80	0.0393	-0.03455	-0.05368	-0.01318	0.040887	0.040837	-0.02544	-0.03656	-0.01399	0.025446	0.023439	-0.00156	-0.01642	-0.0107	0.018339	0.011141	-0.00162	0.184505
81	0.070227	0.033848	-0.00355	-0.04629	-0.00925	0.020791	0.029676	0.008798	-0.03028	-0.01597	-0.00142	0.018794	-0.0012	-0.00926	-0.01246	0.008186	0.016101	0.380669
82	0.024464	0.061434	0.051277	-0.01265	-0.04492	-0.03433	0.031027	0.037117	0.015895	-0.02244	-0.023	-0.00664	0.017088	0.016979	-0.00844	-0.01857	-0.01477	0.468313
83	-0.04801	0.014949	0.03829	0.039232	-0.01035	-0.03153	-0.02384	-0.00647	0.029282	0.020196	0.008612	-0.0159	-0.00833	-0.00224	0.019187	0.008678	-0.00106	0.492386
84	-0.06806	-0.04956	-0.02534	0.034545	0.04041	0.024466	-0.03551	-0.03752	-0.01773	0.018638	0.020302	0.013579	-0.01244	-0.01546	-0.00679	0.010693	0.015853	0.372627
85	-0.01378	-0.05431	-0.05546	-0.01996	0.027976	0.039187	0.017153	0.004108	-0.02817	-0.0237	-0.01496	0.009971	0.015275	0.012713	-0.01378	-0.01839	-0.01507	0.264848
86	0.055545	0.006419	-0.01223	-0.04568	-0.0282	-0.01221	0.038742	0.037782	0.019504	-0.01418	-0.01562	-0.01793	0.003915	0.00685	0.017729	0.006002	-0.00051	0.353617
87	0.064217	0.059413	0.047168	-0.00553	-0.04028	-0.04301	-0.00986	-0.00173	0.026942	0.026373	0.01985	-0.00215	-0.01746	-0.01735	-0.0003	0.012938	0.01559	0.39984
88	0.002763	0.040773	0.044188	0.042593	0.01063	-0.00125	-0.0406	-0.03789	-0.0212	0.009213	0.00941	0.018867	0.005827	0.004907	-0.01749	-0.01775	-0.01537	0.327908
89	-0.06171	-0.02703	-0.01723	0.029299	0.044919	0.042615	0.00222	-0.00065	-0.02561	-0.02811	-0.02279	-0.00608	0.014208	0.014029	0.014195	0.003179	5.4E-05	0.298026
90	-0.05879	-0.06224	-0.05586	-0.02624	0.008968	0.014582	0.041015	0.03785	0.022806	-0.00392	-0.00228	-0.01621	-0.01375	-0.01441	0.006212	0.014864	0.015311	0.172351
91	0.008325	-0.02241	-0.02061	-0.04394	-0.04101	-0.03805	0.0055	0.003023	0.024178	0.028845	0.023507	0.013156	-0.00653	-0.00427	-0.01913	-0.01667	-0.01564	-0.03347
92	0.066352	0.04444	0.041896	0.001725	-0.02686	-0.02649	-0.03998	-0.03766	-0.02432	-0.00151	-0.00508	0.010473	0.0174	0.017302	0.008982	0.000276	0.000614	-0.05046
93	0.051921	0.057709	0.048997	0.044906	0.029289	0.029766	-0.01303	-0.00539	-0.02265	-0.02856	-0.02192	-0.01773	-0.00318	-0.00746	0.011995	0.016423	0.015017	0.077564

94	-0.01921	0.001398	-0.0087	0.023331	0.039637	0.0358	0.037529	0.037322	0.025748	0.006882	0.011934	-0.00274	-0.01563	-0.01225	-0.01851	-0.01519	-0.0159	0.269647
95	-0.06936	-0.0566	-0.05489	-0.03189	-0.012	-0.01856	0.020089	0.007734	0.021032	0.027266	0.018185	0.018921	0.011896	0.015755	0.002707	-0.00263	0.001173	0.482028
96	-0.04377	-0.04635	-0.02849	-0.04112	-0.04487	-0.04161	-0.03375	-0.03684	-0.02707	-0.01201	-0.01762	-0.00552	0.00899	0.001577	0.016359	0.017579	0.014708	0.534061
97	0.029619	0.01978	0.035594	0.008941	-0.00758	0.005547	-0.02644	-0.01005	-0.01933	-0.02501	-0.01267	-0.01651	-0.01691	-0.01682	-0.0157	-0.01333	-0.01615	0.572489
98	0.070664	0.062065	0.052601	0.046113	0.041563	0.043344	0.028771	0.036205	0.028283	0.01672	0.021588	0.01272	0.000447	0.00982	-0.00389	-0.00548	0.001731	0.44702
99	0.034543	0.029518	4.19E-05	0.016789	0.025714	0.008014	0.031856	0.012322	0.017555	0.021858	0.005917	0.010965	0.016663	0.01017	0.018789	0.018301	0.014385	0.61914
100	-0.0393	-0.03862	-0.05257	-0.03674	-0.03034	-0.04884	-0.02278	-0.03543	-0.02939	-0.02083	-0.02344	-0.0175	-0.00974	-0.01671	-0.01104	-0.01114	-0.01638	-2.00773

Heave Time Series

$$\eta(x,t) = \sum\left(\frac{H(n)}{2}\right)\cos[k(n)x - 2\pi f(n)t + \varepsilon(n)]$$

t	η18	η19	η20	η21	η22	η23	η24	η25	η26	η27	η28	η29	η30	η31	η32	η33	η34	η
0	0.000694	0.000661	0.000888	0.000685	0.000488	0.000564	0.000272	0.000367	0.000265	0.000175	0.00021	0.000172	9.23E-05	0.000141	7.51E-05	6.83E-05	9.06E-05	0.027959
1	0.00124	0.001031	0.000602	0.000695	0.000626	0.000287	0.000431	0.000151	0.000142	0.000151	-1.3E-05	3.28E-05	0.000106	-9.7E-06	6.82E-05	5.02E-05	-1.3E-05	0.027661
2	0.000432	0.000157	-0.00048	-0.0003	-0.00021	-0.00047	-0.00019	-0.00036	-0.00027	-0.0002	-0.00021	-0.00019	-0.00015	-0.00013	-0.00013	-0.00011	-7.8E-05	0.008013
3	-0.00085	-0.00091	-0.00093	-0.00086	-0.00072	-0.00044	-0.00047	-0.00017	-0.00012	-0.00011	7.72E-05	4.87E-05	-2.2E-05	0.000101	3.45E-05	5.32E-05	9.18E-05	-0.0095
4	-0.0012	-0.00088	-0.00015	-0.00018	-9.9E-05	0.000338	0.000103	0.000347	0.000282	0.000224	0.000182	0.000166	0.000164	6.6E-05	0.000102	6.55E-05	-1.6E-05	-0.01534
5	-0.00024	0.000209	0.000826	0.000758	0.000676	0.000541	0.000487	0.000195	0.000107	7.01E-05	-0.00013	-0.00012	-7E-05	-0.00015	-0.00012	-0.00011	-7.6E-05	-0.01328
6	0.000981	0.001043	0.000708	0.000606	0.000394	-0.00017	-1.1E-05	-0.00033	-0.00029	-0.00024	-0.00014	-0.00011	-0.00012	3.24E-05	-1E-05	3.68E-05	9.28E-05	-0.00742
7	0.001134	0.000619	-0.00035	-0.00042	-0.0005	-0.00059	-0.00049	-0.00022	-8.9E-05	-2.5E-05	0.000178	0.00017	0.000139	0.000123	0.000124	7.93E-05	-1.9E-05	-0.00179
8	4.88E-05	-0.00055	-0.00094	-0.00084	-0.00061	-1.7E-05	-8.1E-05	0.000321	0.000294	0.000242	8.43E-05	3.86E-05	4.71E-05	-0.00012	-8.8E-05	-0.00011	-7.4E-05	0.001403
9	-0.00109	-0.00106	-0.00029	-4.9E-05	0.000236	0.000589	0.000474	0.000236	7.02E-05	-2E-05	-0.0002	-0.00019	-0.00017	-4.5E-05	-5.4E-05	1.95E-05	9.38E-05	0.003791
10	-0.00104	-0.00029	0.000745	0.000813	0.000717	0.000201	0.00017	-0.00031	-0.0003	-0.00024	-2E-05	4.3E-05	4.53E-05	0.000146	0.000131	9.11E-05	-2.2E-05	0.00558
11	0.000147	0.000828	0.000797	0.000503	7.69E-05	-0.00053	-0.00044	-0.00026	-5.1E-05	6.51E-05	0.000211	0.000168	0.00014	-5.4E-05	-5E-05	-0.0001	-7.2E-05	0.005617
12	0.001172	0.000946	-0.00021	-0.00053	-0.00068	-0.00037	-0.00025	0.00029	0.000302	0.000226	-4.5E-05	-0.00012	-0.00012	-0.00011	-9.1E-05	1.69E-06	9.47E-05	0.004572
13	0.000917	-7.7E-05	-0.00094	-0.0008	-0.00038	0.000411	0.000394	0.000274	3.25E-05	-0.00011	-0.0002	-0.00012	-7.1E-05	0.000129	0.000122	0.000101	-2.5E-05	0.00251
14	-0.00034	-0.00101	-0.00043	8.62E-05	0.00052	0.000494	0.000327	-0.00027	-0.0003	-0.00021	0.000107	0.000168	0.000163	2.24E-05	-6.2E-06	-9.3E-05	-6.9E-05	-0.00113
15	-0.00122	-0.00072	0.000645	0.000848	0.000602	-0.00026	-0.00033	-0.00029	-1.3E-05	0.000146	0.000163	4.43E-05	-2E-05	-0.00014	-0.00012	-1.6E-05	9.55E-05	-0.00474
16	-0.00077	0.000432	0.000866	0.000387	-0.00026	-0.00057	-0.00039	0.000255	0.000304	0.000178	-0.00016	-0.00019	-0.00015	7.5E-05	9.93E-05	0.000108	-2.8E-05	0.00608
17	0.000523	0.001067	-5.9E-05	-0.00063	-0.00071	7.66E-05	0.000259	0.000307	-5.7E-06	-0.00018	-0.00011	3.73E-05	0.000105	9.29E-05	3.84E-05	-8.2E-05	-6.7E-05	-0.0043
18	0.001248	0.000415	-0.00091	-0.00074	-5.4E-05	0.000599	0.000439	-0.00024	-0.0003	-0.00014	0.000193	0.000171	9.39E-05	-0.00014	-0.00013	-3.4E-05	9.63E-05	-0.00018

19	0.00061	-0.00074	-0.00056	0.000219	0.000691	0.000111	-0.00018	-0.00032	2.48E-05	0.000207	5.3E-05	-0.00011	-0.00016	4.99E-07	6.47E-05	0.000112	-3.1E-05	0.0031
20	-0.00069	-0.001	0.00053	0.000862	0.000356	-0.00056	-0.00047	0.000215	0.000303	0.000106	-0.00021	-0.00012	-6.2E-06	0.000138	7.84E-05	-6.8E-05	-6.5E-05	0.004069
21	-0.00124	-5.7E-05	0.000914	0.000262	-0.00054	-0.00029	8.76E-05	0.000335	-4.4E-05	-0.00023	1.27E-05	0.000165	0.000161	-9.4E-05	-0.00013	-5E-05	8.69E-05	0.002681
22	-0.00043	0.000955	8.95E-05	-0.00072	-0.00059	0.000474	0.000488	-0.00019	-0.0003	-6.3E-05	0.000206	5E-05	-8.3E-05	-7.4E-05	2.25E-05	0.000114	-3.4E-05	0.000445
23	0.000848	0.000816	-0.00085	-0.00066	0.000278	0.000435	4.28E-06	-0.00035	6.27E-05	0.000239	-7.7E-05	-0.00019	-0.00011	0.000144	0.000109	-5.3E-05	-6.3E-05	-0.00099
24	0.001202	-0.00031	-0.00067	0.000347	0.000711	-0.00034	-0.00049	0.000172	0.000296	1.78E-05	-0.00018	3.15E-05	0.000147	-2.3E-05	-0.00011	-6.6E-05	8.74E-05	-0.00116
25	0.000243	-0.00106	0.000401	0.000855	3.17E-05	-0.00054	-9.6E-05	0.000358	-8.1E-05	-0.00024	0.000134	0.000173	3.2E-05	-0.00013	-2.2E-05	0.000113	-3.7E-05	-0.00115
26	-0.00098	-0.00053	0.000939	0.00013	-0.0007	0.000169	0.000469	-0.00015	-0.00029	2.78E-05	0.00014	-0.00011	-0.00016	0.00011	0.000127	-3.7E-05	-6E-05	-0.00137
27	-0.00113	0.000635	0.000235	-0.00078	-0.00034	0.000594	0.000184	-0.00037	9.95E-05	0.000237	-0.00018	-0.00013	6E-05	5.34E-05	-7.8E-05	-7.9E-05	8.78E-05	-0.00096
28	-4.9E-05	0.001039	-0.00078	-0.00057	0.00055	1.73E-05	-0.00043	0.000127	0.000285	-7.2E-05	-8.4E-05	0.000162	0.000131	-0.00015	-6.5E-05	0.000109	-3.9E-05	0.000314
29	0.00109	0.00019	-0.00076	0.000466	0.000576	-0.00059	-0.00027	0.000375	-0.00012	-0.00022	0.000204	5.56E-05	-0.00013	4.57E-05	0.00013	-1.9E-05	-5.8E-05	0.001459
30	0.001038	-0.00089	0.000263	0.000827	-0.0003	-0.0002	0.000385	-0.0001	-0.00028	0.000114	2.04E-05	-0.00019	-5.7E-05	0.000115	-3.8E-05	-9.1E-05	6.82E-05	0.001586
31	-0.00015	-0.0009	0.000942	-5.1E-06	-0.00071	0.000526	0.000339	-0.00038	0.000135	0.000202	-0.00021	2.57E-05	0.000165	-0.00012	-9.9E-05	0.000102	-4.2E-05	0.000544
32	-0.00117	0.000176	0.000375	-0.00083	-9E-06	0.000366	-0.00032	7.91E-05	0.000269	-0.00015	4.55E-05	0.000175	-3.5E-05	-3.1E-05	0.000117	-1.7E-06	-5.5E-05	-0.00111
33	-0.00092	0.001035	-0.00069	-0.00046	0.000702	-0.00041	-0.0004	0.000387	-0.00015	-0.00017	0.000196	-0.0001	-0.00015	0.000145	6.13E-06	-0.0001	8.84E-05	-0.00197
34	0.000339	0.000646	-0.00084	0.000574	0.000315	-0.00049	0.000246	-5.5E-05	-0.00026	0.000185	-0.00011	-0.00013	0.000116	-6.7E-05	-0.00012	9.31E-05	-4.5E-05	-0.00062
35	0.001225	-0.00052	0.000118	0.000778	-0.00056	0.000256	0.000445	-0.00039	0.000168	0.000138	-0.00016	0.000159	8.06E-05	-1E-04	9.09E-05	1.61E-05	-5.3E-05	0.001795
36	0.000773	-0.00106	0.000921	-0.00014	-0.00056	0.000575	-0.00016	3.03E-05	0.000249	-0.00021	0.000158	6.12E-05	-0.00016	0.000135	5E-05	-0.00011	9.85E-05	0.002211
37	-0.00052	-0.00032	0.000506	-0.00086	0.00032	-7.7E-05	-0.00048	0.000392	-0.00018	-9.9E-05	0.000114	-0.00019	9.43E-06	8.7E-06	-0.00013	8.17E-05	-4.8E-05	0.000551
38	-0.00125	0.000806	-0.00058	-0.00034	0.000701	-0.0006	7.24E-05	-5.6E-06	-0.00024	0.00023	-0.00019	1.99E-05	0.000156	-0.00014	5.38E-05	3.36E-05	-5E-05	-0.00049
39	-0.00061	0.000961	-0.0009	0.000668	-1.4E-05	-0.00011	0.000489	-0.00039	0.000198	5.54E-05	-5.3E-05	0.000177	-9.7E-05	8.65E-05	8.79E-05	-0.00011	9.86E-05	-0.00074
40	0.000694	-4.3E-05	-3E-05	0.00071	-0.00071	0.000564	1.97E-05	-1.9E-05	0.000225	-0.00024	0.00021	-9.7E-05	-0.0001	8.19E-05	-0.00012	6.83E-05	-5E-05	-0.00158
41	0.00124	-0.001	0.000877	-0.00027	-0.00029	0.000287	-0.00049	0.000391	-0.00021	-1E-05	-1.3E-05	-0.00013	0.000154	-0.00014	1.03E-05	5.02E-05	-4.7E-05	-0.00207
42	0.000432	-0.00075	0.000624	-0.00086	0.000579	-0.00047	-0.00011	4.36E-05	-0.00021	0.000242	-0.00021	0.000156	1.65E-05	1.43E-05	0.000115	-0.00011	9.85E-05	-0.00113
43	-0.00085	0.000402	-0.00045	-0.00021	0.000547	-0.00044	0.000465	-0.00039	0.000226	-3.5E-05	7.72E-05	6.67E-05	-0.00016	0.000132	-0.0001	5.32E-05	-5.3E-05	0.000468
44	-0.0012	0.001066	-0.00093	0.000745	-0.00034	0.000338	0.000199	-6.8E-05	0.000197	-0.00024	0.000182	-0.00019	7.43E-05	-0.0001	-3.4E-05	6.55E-05	-4.4E-05	0.001755

45	-0.00024	0.000445	-0.00018	0.000625	-0.0007	0.000541	-0.00043	0.000384	-0.00024	7.97E-05	-0.00013	1.4E-05	0.000121	-6.2E-05	0.000129	-0.00011	9.84E-05	0.001987
46	0.000981	-0.00071	0.000812	-0.0004	3.63E-05	-0.00017	-0.00028	9.21E-05	-0.00018	0.00022	-0.00014	0.000179	-0.00014	0.000146	-6.8E-05	3.68E-05	-5.6E-05	0.001151
47	0.001134	-0.00101	0.000727	-0.00085	0.000711	-0.00059	0.000375	-0.00038	0.00025	-0.00012	0.000178	-4.2E-05	-4.2E-05	-3.7E-05	-7.5E-05	7.93E-05	-4.2E-05	0.00054
48	4.88E-05	-9.1E-05	-0.00032	-7.6E-05	0.000274	-1.7E-05	0.000349	-0.00012	0.000166	-0.0002	8.43E-05	-0.00014	0.000166	-0.00012	0.000128	-0.00011	9.81E-05	0.000438
49	-0.00109	0.000939	-0.00094	0.000804	-0.00059	0.000589	-0.00031	0.000371	-0.00026	0.000158	-0.0002	0.000153	-5E-05	0.000119	-2.7E-05	1.95E-05	-5.8E-05	-0.00025
50	-0.00104	0.000837	-0.00032	0.000525	-0.00053	0.000201	-0.00041	0.000139	-0.00015	0.000168	-2E-05	7.22E-05	-0.00014	4.04E-05	-0.00011	9.11E-05	-3.9E-05	-0.00137
51	0.000147	-0.00027	0.000727	-0.00051	0.00036	-0.00053	0.000232	-0.00036	0.00027	-0.00019	0.000211	-0.00018	0.000127	-0.00015	0.000111	-0.0001	9.78E-05	-0.00187
52	0.001172	-0.00105	0.000812	-0.00081	0.000689	-0.00037	0.000451	-0.00016	0.000133	-0.00013	-4.5E-05	8.15E-06	6.66E-05	5.86E-05	1.84E-05	1.69E-06	-6.1E-05	-0.00164
53	0.000917	-0.00056	-0.00018	5.92E-05	-5.9E-05	0.000411	-0.00015	0.000352	-0.00028	0.000215	-0.0002	0.000181	-0.00016	0.000106	-0.00013	0.000101	-3.6E-05	-0.00109
54	-0.00034	0.000607	-0.00093	0.000843	-0.00071	0.000494	-0.00048	0.000184	-0.00012	9.16E-05	0.000107	-8.7E-05	2.49E-05	-0.00013	8.17E-05	-9.3E-05	9.73E-05	-0.00023
55	-0.00122	0.001046	-0.00046	0.000411	-0.00025	-0.00026	5.72E-05	-0.00034	0.000285	-0.00023	0.000163	-0.00014	0.00015	-1.8E-05	6.11E-05	-1.6E-05	-6.3E-05	0.001122
56	-0.00077	0.000223	0.000623	-0.00061	0.000605	-0.00057	0.00049	-0.00021	9.77E-05	-4.8E-05	-0.00016	0.000149	-0.00011	0.000143	-0.00013	0.000108	-3.3E-05	0.002494
57	0.000523	-0.00087	0.000878	-0.00075	0.000517	7.66E-05	3.5E-05	0.000328	-0.00029	0.000241	-0.00011	7.75E-05	-9E-05	-7.9E-05	4.23E-05	-8.2E-05	9.68E-05	0.002622
58	0.001248	-0.00091	-2.9E-05	0.000193	-0.00038	0.000599	-0.00048	0.000226	-7.9E-05	2.58E-06	0.000193	-0.00018	0.000159	-8.9E-05	9.66E-05	-3.4E-05	-6.5E-05	0.001146
59	0.00061	0.000143	-0.0009	0.000861	-0.00068	0.000111	-0.00013	-0.00031	0.000296	-0.00024	5.3E-05	2.28E-06	9.72E-07	0.000139	-0.00012	0.000112	-3E-05	-0.00071
60	-0.00069	0.001027	-0.00058	0.000287	8.15E-05	-0.00056	0.00046	-0.00025	6.08E-05	4.29E-05	-0.00021	0.000182	-0.00016	-5.1E-06	-2E-06	-6.8E-05	9.61E-05	-0.0016
61	-0.00124	0.000672	0.000505	-0.0007	0.000718	-0.00029	0.000212	0.000298	-0.0003	0.000233	1.27E-05	-4.2E-05	8.79E-05	-0.00014	0.000121	-5E-05	-6.8E-05	-0.00116
62	-0.00043	-0.00049	0.000921	-0.00068	0.000232	0.000474	-0.00042	0.000265	-4.2E-05	-8.7E-05	0.000206	-0.00015	0.00011	9.72E-05	-9.4E-05	0.000114	-2.7E-05	-0.001
63	0.000848	-0.00106	0.000119	0.000322	-0.00062	0.000435	-0.00029	-0.00028	0.000303	-0.00022	-7.7E-05	0.000146	-0.00015	7.01E-05	-4.6E-05	-5.3E-05	9.54E-05	-0.00089
64	0.001202	-0.00035	-0.00084	0.000858	-0.0005	-0.00034	0.000365	-0.00028	2.29E-05	0.000128	-0.00018	8.28E-05	-2.7E-05	-0.00014	0.00013	-6.6E-05	-7E-05	0.000159
65	0.000243	0.000784	-0.00069	0.000157	0.000398	-0.00054	0.00036	0.000264	-0.0003	0.000193	0.000134	-0.00018	0.000164	2.79E-05	-5.7E-05	0.000113	-2.4E-05	0.001599
66	-0.00098	0.000975	0.000374	-0.00077	0.000674	0.000169	-0.0003	0.000299	-3.8E-06	-0.00016	0.00014	-1.6E-06	-6.5E-05	0.000126	-8.5E-05	-3.7E-05	5.48E-05	0.000843
67	-0.00113	-9.6E-06	0.000942	-0.00059	-0.0001	0.000594	-0.00042	-0.00025	0.000304	-0.00016	-0.00018	0.000183	-0.00013	-0.00011	0.000125	-7.9E-05	-7.2E-05	-0.00141
68	-4.9E-05	-0.00098	0.000264	0.000443	-0.00072	1.73E-05	0.000219	-0.00031	-1.5E-05	0.000195	-8.4E-05	-7.6E-05	0.000136	-4.9E-05	-1.4E-05	0.000109	-2.1E-05	-0.00204
69	0.00109	-0.00077	-0.00076	0.000834	-0.00021	-0.00059	0.000457	0.000225	-0.0003	0.000126	0.000204	-0.00015	5.21E-05	0.000146	-0.00011	-1.9E-05	9.37E-05	-0.00075
70	0.001038	0.00037	-0.00078	2.2E-05	0.000628	-0.0002	-0.00013	0.000328	3.44E-05	-0.00022	2.04E-05	0.000142	-0.00017	-5E-05	0.000104	-9.1E-05	-7.4E-05	0.001173

71	-0.00015	0.001065	0.000234	-0.00082	0.000484	0.000526	-0.00048	-0.0002	0.000301	-8.5E-05	-0.00021	8.81E-05	4.02E-05	-0.00011	3.05E-05	0.000102	-1.8E-05	0.002903
72	-0.00117	0.000476	0.000939	-0.00048	-0.00042	0.000366	4.19E-05	-0.00034	-5.3E-05	0.000234	4.55E-05	-0.00018	0.000143	0.000126	-0.00013	-1.7E-06	9.26E-05	0.001067
73	-0.00092	-0.00069	0.000402	0.000554	-0.00067	-0.00041	0.00049	0.000183	-0.0003	4.05E-05	0.000196	-9.5E-06	-0.00012	2.69E-05	7.17E-05	-0.0001	-7.6E-05	0.001566
74	0.000339	-0.00102	-0.00067	0.000789	0.000126	-0.00049	5.04E-05	0.000353	7.2E-05	-0.00024	-0.00011	0.000184	-7.6E-05	-0.00014	7.17E-05	9.31E-05	-1.5E-05	-2.2E-05
75	0.001225	-0.00012	-0.00085	-0.00011	0.000721	0.000256	-0.00048	-0.00016	0.000293	5.04E-06	-0.00016	-7.1E-05	0.000162	7.1E-05	-0.00013	1.61E-05	9.15E-05	-0.00133
76	0.000773	0.000923	8.81E-05	-0.00085	0.000188	0.000575	-0.00014	-0.00036	-9E-05	0.000241	0.000158	-0.00015	-1.5E-05	9.65E-05	3.05E-05	-0.00011	-7.8E-05	-0.00256
77	-0.00052	0.000857	0.000914	-0.00036	-0.00064	-7.7E-05	0.000454	0.000138	-0.00029	-5E-05	0.000114	0.000138	-0.00015	-0.00014	0.000104	8.17E-05	-1.2E-05	-0.00333
78	-0.00125	-0.00024	0.000531	0.00065	-0.00047	-0.0006	0.000226	0.000372	0.000109	-0.00023	-0.00019	9.32E-05	0.000101	-4.1E-06	-0.00011	3.36E-05	9.03E-05	-0.00351
79	-0.00061	-0.00105	-0.00055	0.000725	0.000435	-0.00011	-0.00041	-0.00011	0.000281	9.39E-05	-5.3E-05	-0.00018	9.81E-05	0.000139	-1.4E-05	-0.00011	-8E-05	-0.00244
80	0.000694	-0.00059	-0.00091	-0.00025	0.000657	0.000564	-0.0003	-0.00038	-0.00013	0.000214	0.00021	-1.5E-05	-0.00016	-9E-05	0.000125	6.83E-05	-9E-06	0.000313
81	0.00124	0.00058	-6E-05	-0.00086	-0.00015	0.000287	0.000354	9.11E-05	-0.00027	-0.00013	-1.3E-05	0.000185	-1.1E-05	-7.8E-05	-8.5E-05	5.02E-05	8.91E-05	0.001126
82	0.000432	0.001052	0.000866	-0.00024	-0.00072	-0.00047	0.00037	0.000384	0.000143	-0.00019	-0.00021	-6.5E-05	0.000162	0.000143	-5.7E-05	-0.00011	-8.2E-05	0.00445
83	-0.00085	0.000256	0.000646	0.000731	-0.00017	-0.00044	-0.00028	-6.7E-05	0.000264	0.00017	7.72E-05	-0.00016	-7.9E-05	-1.9E-05	0.00013	5.32E-05	-5.9E-06	0.003872
84	-0.0012	-0.00085	-0.00043	0.000644	0.000649	0.000338	-0.00042	-0.00039	-0.00016	0.000156	0.000182	0.000134	-0.00012	-0.00013	-4.6E-05	6.55E-05	8.77E-05	0.001539
85	-0.00024	-0.00093	-0.00094	-0.00037	0.000449	0.000541	0.000205	4.26E-05	-0.00025	-0.0002	-0.00013	9.83E-05	0.000145	0.000107	-9.4E-05	-0.00011	-8.3E-05	-0.00047
86	0.000981	0.00011	-0.00021	-0.00085	-0.00045	-0.00017	0.000462	0.000391	0.000176	-0.00012	-0.00014	-0.00018	3.71E-05	5.77E-05	0.000121	3.68E-05	-2.8E-06	-0.00034
87	0.001134	0.001017	0.000796	-0.0001	-0.00065	-0.00059	-0.00012	-1.8E-05	0.000243	0.000221	0.000178	-2.1E-05	-0.00017	-0.00015	-2.1E-06	7.93E-05	8.62E-05	0.000552
88	4.88E-05	0.000698	0.000746	0.000793	0.000171	-1.7E-05	-0.00048	-0.00039	-0.00019	7.73E-05	8.43E-05	0.000186	5.52E-05	4.13E-05	-0.00012	-0.00011	-8.5E-05	0.000653
89	-0.00109	-0.00046	-0.00029	0.000546	0.000722	0.000589	2.65E-05	-6.7E-06	-0.00023	-0.00024	-0.0002	-6E-05	0.000135	0.000118	9.66E-05	1.95E-05	2.99E-07	-0.00069
90	-0.00104	-0.00107	-0.00094	-0.00049	0.000144	0.000201	0.00049	0.000392	0.000206	-3.3E-05	-2E-05	-0.00016	-0.00013	-0.00012	4.23E-05	9.11E-05	8.47E-05	-0.00418
91	0.000147	-0.00038	-0.00035	-0.00082	-0.00066	-0.00053	6.57E-05	3.13E-05	0.000218	0.000242	0.000211	0.00013	-6.2E-05	-3.6E-05	-0.00013	-0.0001	-8.7E-05	-0.00762
92	0.001172	0.000761	0.000707	3.21E-05	-0.00043	-0.00037	-0.00048	-0.00039	-0.00022	-1.3E-05	-4.5E-05	0.000103	0.000165	0.000146	6.11E-05	1.69E-06	3.39E-06	-0.00758
93	0.000917	0.000988	0.000827	0.000837	0.000471	0.000411	-0.00016	-5.6E-05	-0.0002	-0.00024	-0.0002	-0.00017	-3E-05	-6.3E-05	8.16E-05	0.000101	8.31E-05	-0.00406
94	-0.00034	2.39E-05	-0.00015	0.000435	0.000637	0.000494	0.000448	0.000387	0.000232	5.78E-05	0.000107	-2.7E-05	-0.00015	-0.0001	-0.00013	-9.3E-05	-8.8E-05	0.001651
95	-0.00122	-0.00097	-0.00093	-0.00059	-0.00019	-0.00026	0.00024	8.01E-05	0.00019	0.000229	0.000163	0.000186	0.000113	0.000133	1.84E-05	-1.6E-05	6.49E-06	0.008338
96	-0.00077	-0.00079	-0.00048	-0.00077	-0.00072	-0.00057	-0.0004	-0.00038	-0.00024	-0.0001	-0.00016	-5.4E-05	8.51E-05	1.33E-05	0.000111	0.000108	8.14E-05	0.018102

97	0.000523	0.000339	0.000601	0.000167	-0.00012	7.66E-05	-0.00032	-0.0001	-0.00017	-0.00021	-0.00011	-0.00016	-0.00016	-0.00014	-0.00011	-8.2E-05	-8.9E-05	0.017978
98	0.001248	0.001063	0.000888	0.000859	0.000668	0.000599	0.000343	0.000375	0.000255	0.00014	0.000193	0.000125	4.23E-06	8.27E-05	-2.6E-05	-3.4E-05	9.57E-06	0.012967
99	0.00061	0.000505	7.08E-07	0.000313	0.000413	0.000111	0.00038	0.000128	0.000158	0.000183	5.3E-05	0.000108	0.000158	8.57E-05	0.000128	0.000112	7.96E-05	-0.00684
100	-0.00069	-0.00066	-0.00089	-0.00068	-0.00049	-0.00056	-0.00027	-0.00037	-0.00026	-0.00017	-0.00021	-0.00017	-9.2E-05	-0.00014	-7.5E-05	-6.8E-05	-9.1E-05	-0.02796

<u>Pitch Time Series</u>

$$\eta(x,t) = \sum\left(\frac{H(n)}{2}\right)\cos[k(n)x - 2\pi f(n)t + \varepsilon(n)]$$

t	η18	η19	η20	η21	η22	η23	η24	η25	η26	η27	η28	η29	η30	η31	η32	η33	η34	η
0	0.000482	0.000469	0.000658	0.000496	0.000337	0.000379	0.000216	0.000342	0.000289	0.000208	0.000243	0.000187	9.23E-05	0.000126	6.9E-05	7.03E-05	0.000103	1.653536
1	0.000861	0.000732	0.000446	0.000504	0.000433	0.000193	0.000343	0.00014	0.000155	0.000179	-1.5E-05	3.56E-05	0.000106	-8.7E-06	6.27E-05	5.16E-05	-1.4E-05	1.672266
2	0.0003	0.000112	-0.00036	-0.00022	-0.00015	-0.00032	-0.00015	-0.00033	-0.0003	-0.00024	-0.00024	-0.0002	-0.00015	-0.00012	-0.00012	-0.00012	-8.9E-05	0.828761
3	-0.00059	-0.00064	-0.00069	-0.00062	-0.0005	-0.00029	-0.00037	-0.00016	-0.00014	-0.00013	8.92E-05	5.29E-05	-2.2E-05	9.02E-05	3.17E-05	5.47E-05	0.000105	0.116808
4	-0.00083	-0.00062	-0.00011	-0.00013	-6.9E-05	0.000227	8.16E-05	0.000323	0.000308	0.000267	0.00021	0.00018	0.000164	5.92E-05	9.36E-05	6.74E-05	-1.8E-05	-0.14782
5	-0.00017	0.000149	0.000612	0.00055	0.000467	0.000364	0.000387	0.000182	0.000117	8.34E-05	-0.00016	-0.00013	-7E-05	-0.00013	-0.00011	-0.00012	-8.7E-05	-0.17623
6	0.000681	0.00074	0.000525	0.00044	0.000273	-0.00011	-8.8E-06	-0.00031	-0.00031	-0.00028	-0.00016	-0.00012	-0.00012	2.91E-05	-9.4E-06	3.79E-05	0.000106	-0.03716
7	0.000788	0.000439	-0.00026	-0.0003	-0.00035	-0.0004	-0.00039	-0.0002	-9.7E-05	-3E-05	0.000206	0.000185	0.000139	0.000111	0.000114	8.16E-05	-2.1E-05	0.137754
8	3.39E-05	-0.00039	-0.0007	-0.00061	-0.00042	-1.2E-05	-6.4E-05	0.000299	0.000321	0.000288	9.75E-05	4.19E-05	4.71E-05	-0.0001	-8.1E-05	-0.00011	-8.4E-05	0.199628
9	-0.00076	-0.00075	-0.00022	-3.6E-05	0.000163	0.000396	0.000376	0.00022	7.66E-05	-2.4E-05	-0.00024	-0.0002	-0.00017	-4E-05	-4.9E-05	2E-05	0.000107	0.215634
10	-0.00072	-0.0002	0.000552	0.00059	0.000496	0.000135	0.000135	-0.00029	-0.00033	-0.00028	-2.4E-05	4.67E-05	4.53E-05	0.000131	0.00012	9.37E-05	-2.5E-05	0.233019
11	0.000102	0.000588	0.000591	0.000365	5.32E-05	-0.00035	-0.00035	-0.00024	-5.6E-05	7.75E-05	0.000244	0.000183	0.00014	-4.9E-05	-4.6E-05	-0.00011	-8.2E-05	0.204322
12	0.000814	0.000671	-0.00015	-0.00039	-0.00047	-0.00025	-0.0002	0.00027	0.000329	0.000269	-5.3E-05	-0.00013	-0.00012	-9.8E-05	-8.4E-05	1.74E-06	0.000108	0.125612
13	0.000637	-5.4E-05	-0.00069	-0.00058	-0.00026	0.000277	0.000313	0.000255	3.55E-05	-0.00013	-0.00023	-0.00013	-7.1E-05	0.000115	0.000112	0.000104	-2.8E-05	-0.01392
14	-0.00024	-0.00071	-0.00032	6.25E-05	0.00036	0.000333	0.00026	-0.00025	-0.00033	-0.00025	0.000124	0.000182	0.000163	2.01E-05	-5.7E-06	-9.6E-05	-7.9E-05	-0.20654
15	-0.00085	-0.00051	0.000478	0.000615	0.000416	-0.00017	-0.00026	-0.00027	-1.5E-05	0.000174	0.000188	4.81E-05	-2E-05	-0.00013	-0.00011	-1.7E-05	0.000109	-0.37089
16	-0.00054	0.000307	0.000642	0.000281	-0.00018	-0.00039	-0.00031	0.000237	0.000332	0.000212	-0.00018	-0.0002	-0.00015	6.72E-05	9.13E-05	0.000111	-3.2E-05	-0.44317
17	0.000363	0.000757	-4.3E-05	-0.00046	-0.00049	5.15E-05	0.000206	0.000286	-6.3E-06	-0.00021	-0.00013	4.05E-05	0.000105	8.34E-05	3.53E-05	-8.4E-05	-7.7E-05	-0.39623
18	0.000867	0.000294	-0.00067	-0.00054	-3.8E-05	0.000403	0.000348	-0.00022	-0.00033	-0.00017	0.000224	0.000185	9.39E-05	-0.00012	-0.00012	-3.5E-05	0.00011	-0.24985

19	0.000424	-0.00052	-0.00041	0.000159	0.000477	7.45E-05	-0.00014	-0.0003	2.71E-05	0.000247	6.13E-05	-0.00012	-0.00016	4.48E-07	5.95E-05	0.000115	-3.5E-05	-0.1112
20	-0.00048	-0.00071	0.000393	0.000625	0.000246	-0.00038	-0.00037	0.000201	0.00033	0.000126	-0.00024	-0.00013	-6.2E-06	0.000123	7.2E-05	-7E-05	-7.4E-05	-0.07023
21	-0.00086	-4.1E-05	0.000677	0.00019	-0.00037	-0.00019	6.96E-05	0.000312	-4.8E-05	-0.00027	1.47E-05	0.000179	0.000161	-8.4E-05	-0.00012	-5.2E-05	0.000111	-0.12407
22	-0.0003	0.000678	6.63E-05	-0.00052	-0.00041	0.000319	0.000388	-0.00018	-0.00033	-7.5E-05	0.000238	5.43E-05	-8.3E-05	-6.6E-05	2.07E-05	0.000117	-3.8E-05	-0.21672
23	0.000589	0.000579	-0.00063	-0.00048	0.000192	0.000293	3.4E-06	-0.00032	6.84E-05	0.000284	-8.9E-05	-0.0002	-0.00011	0.000129	0.0001	-5.5E-05	-7.2E-05	-0.26435
24	0.000835	-0.00022	-0.00049	0.000252	0.000491	-0.00023	-0.00039	0.000161	0.000323	2.12E-05	-0.00021	3.42E-05	0.000147	-2.1E-05	-0.0001	-6.7E-05	0.000111	-0.24338
25	0.000169	-0.00075	0.000297	0.00062	2.19E-05	-0.00036	-7.6E-05	0.000334	-8.9E-05	-0.00029	0.000155	0.000188	3.2E-05	-0.00011	-2.1E-05	0.000116	-4.2E-05	-0.22558
26	-0.00068	-0.00038	0.000696	9.42E-05	-0.00048	0.000113	0.000373	-0.00014	-0.00032	3.31E-05	0.000162	-0.00012	-0.00016	9.88E-05	0.000117	-3.8E-05	-6.9E-05	-0.22828
27	-0.00079	0.00045	0.000174	-0.00057	-0.00023	0.0004	0.000146	-0.00034	0.000109	0.000282	-0.00021	-0.00014	6.01E-05	4.79E-05	-7.2E-05	-8.2E-05	0.000112	-0.18797
28	-3.4E-05	0.000737	-0.00058	-0.00041	0.000381	1.16E-05	-0.00035	0.000118	0.000311	-8.6E-05	-9.7E-05	0.000176	0.000131	-0.00013	-5.9E-05	0.000112	-4.5E-05	-0.09905
29	0.000757	0.000135	-0.00057	0.000338	0.000398	-0.0004	-0.00021	0.00035	-0.00013	-0.00027	0.000236	6.04E-05	-0.00013	4.1E-05	0.000119	-2E-05	-6.6E-05	-0.01519
30	0.000721	-0.00063	0.000195	0.0006	-0.00021	-0.00014	0.000306	-8.6E-05	-0.0003	0.000136	2.36E-05	-0.0002	-5.7E-05	0.000103	-3.5E-05	-9.4E-05	0.000112	0.031529
31	-0.0001	-0.00064	0.000698	-3.7E-06	-0.00049	0.000354	0.000269	-0.00036	0.000147	0.00024	-0.00024	2.79E-05	0.000165	-0.00011	-9.1E-05	0.000105	-4.8E-05	0.031054
32	-0.00081	0.000125	0.000278	-0.0006	-6.2E-06	0.000246	-0.00025	7.37E-05	0.000293	-0.00018	5.26E-05	0.00019	-3.5E-05	-2.8E-05	0.000108	-1.7E-06	-6.3E-05	-0.01226
33	-0.00064	0.000735	-0.00051	-0.00033	0.000486	-0.00028	-0.00032	0.000361	-0.00017	-0.00021	0.000227	-0.00011	-0.00015	0.00013	5.63E-06	-0.0001	0.000112	-0.04357
34	0.000236	0.000459	-0.00062	0.000416	0.000218	-0.00033	0.000195	-5.1E-05	-0.00028	0.00022	-0.00012	-0.00014	0.000116	-6E-05	-0.00011	9.58E-05	-5.1E-05	0.019052
35	0.000851	-0.00037	8.71E-05	0.000564	-0.00039	0.000173	0.000354	-0.00036	0.000183	0.000165	-0.00019	0.000173	8.06E-05	-9E-05	8.35E-05	1.66E-05	-6E-05	0.141465
36	0.000537	-0.00075	0.000682	-0.0001	-0.00039	0.000387	-0.00013	2.82E-05	0.000271	-0.00025	0.000183	6.65E-05	-0.00016	0.000121	4.59E-05	-0.00011	0.000113	0.175853
37	-0.00036	-0.00023	0.000375	-0.00062	0.000221	-5.2E-05	-0.00038	0.000366	-0.0002	-0.00012	0.000131	-0.0002	9.43E-06	7.8E-06	-0.00012	8.41E-05	-5.5E-05	0.11421
38	-0.00087	0.000572	-0.00043	-0.00025	0.000485	-0.0004	5.76E-05	-5.3E-06	-0.00026	0.000273	-0.00022	2.16E-05	0.000156	-0.00013	4.94E-05	3.45E-05	-5.7E-05	0.08992
39	-0.00042	0.000682	-0.00067	0.000484	-9.5E-06	-7.4E-05	0.000389	-0.00037	0.000217	6.59E-05	-6.1E-05	0.000192	-9.7E-05	7.76E-05	8.08E-05	-0.00012	0.000113	0.101928
40	0.000482	-3.1E-05	-2.2E-05	0.000515	-0.00049	0.000379	1.56E-05	-1.8E-05	0.000245	-0.00029	0.000243	-0.00011	-0.0001	7.34E-05	-0.00011	7.03E-05	-5.8E-05	0.079402
41	0.000861	-0.00071	0.00065	-0.0002	-0.0002	0.000193	-0.00039	0.000365	-0.00023	-1.2E-05	-1.5E-05	-0.00015	0.000154	-0.00013	9.44E-06	5.16E-05	-5.4E-05	0.081272
42	0.0003	-0.00053	0.000463	-0.00063	0.0004	-0.00032	-8.8E-05	4.06E-05	-0.00023	0.000288	-0.00024	0.000169	1.66E-05	1.28E-05	0.000106	-0.00012	0.000113	0.152351
43	-0.00059	0.000285	-0.00034	-0.00015	0.000378	-0.00029	0.000369	-0.00036	0.000247	-4.2E-05	8.92E-05	7.24E-05	-0.00016	0.000119	-9.4E-05	5.47E-05	-6.1E-05	0.233787
44	-0.00083	0.000757	-0.00069	0.00054	-0.00023	0.000227	0.000158	-6.3E-05	0.000215	-0.00028	0.00021	-0.0002	7.43E-05	-9.3E-05	-3.2E-05	6.74E-05	-5.1E-05	0.286027

45	-0.00017	0.000316	-0.00013	0.000453	-0.00048	0.000364	-0.00034	0.000358	-0.00026	9.48E-05	-0.00016	1.52E-05	0.000121	-5.6E-05	0.000119	-0.00012	0.000112	0.287961
46	0.000681	-0.00051	0.000602	-0.00029	2.51E-05	-0.00011	-0.00022	8.59E-05	-0.0002	0.000262	-0.00016	0.000194	-0.00014	0.000131	-6.3E-05	3.79E-05	-6.4E-05	0.236955
47	0.000788	-0.00072	0.000539	-0.00061	0.000492	-0.0004	0.000298	-0.00035	0.000273	-0.00014	0.000206	-1E-04	-4.2E-05	-3.3E-05	-6.9E-05	8.16E-05	-4.8E-05	0.191306
48	3.39E-05	-6.4E-05	-0.00024	-5.5E-05	0.000189	-1.2E-05	0.000278	-0.00011	0.000182	-0.00024	9.75E-05	-0.00015	0.000166	-0.00011	0.000118	-0.00011	0.000112	0.164669
49	-0.00076	0.000667	-0.0007	0.000583	-0.00041	0.000396	-0.00025	0.000346	-0.00028	0.000188	-0.00024	0.000166	-5E-05	0.000107	-2.4E-05	2E-05	-6.6E-05	0.109404
50	-0.00072	0.000594	-0.00024	0.00038	-0.00037	0.000135	-0.00032	0.00013	-0.00016	0.0002	-2.4E-05	7.84E-05	-0.00014	3.62E-05	-9.8E-05	9.37E-05	-4.4E-05	0.036756
51	0.000102	-0.00019	0.000538	-0.00037	0.000249	-0.00035	0.000185	-0.00034	0.000294	-0.00023	0.000244	-0.0002	0.000127	-0.00013	0.000102	-0.00011	0.000112	-0.01295
52	0.000814	-0.00075	0.000602	-0.00059	0.000477	-0.00025	0.000359	-0.00015	0.000145	-0.00016	-5.3E-05	8.85E-06	6.67E-05	5.26E-05	1.69E-05	1.74E-06	-6.9E-05	-0.03755
53	0.000637	-0.0004	-0.00013	4.29E-05	-4.1E-05	0.000277	-0.00012	0.000328	-0.0003	0.000256	-0.00023	0.000196	-0.00016	9.54E-05	-0.00012	0.000104	-4.1E-05	-0.04288
54	-0.00024	0.000431	-0.00069	0.000611	-0.00049	0.000333	-0.00038	0.000172	-0.00013	0.000109	0.000124	-9.4E-05	2.49E-05	-0.00012	7.51E-05	-9.6E-05	0.000111	-0.03275
55	-0.00085	0.000742	-0.00034	0.000298	-0.00017	-0.00017	4.54E-05	-0.00032	0.000311	-0.00028	0.000188	-0.00015	0.00015	-1.6E-05	5.61E-05	-1.7E-05	-7.2E-05	-0.00739
56	-0.00054	0.000158	0.000462	-0.00044	0.000418	-0.00039	0.000389	-0.00019	0.000107	-5.7E-05	-0.00018	0.000162	-0.00011	0.000128	-0.00012	0.000111	-3.8E-05	0.020669
57	0.000363	-0.00062	0.00065	-0.00055	0.000357	5.15E-05	2.78E-05	0.000306	-0.00032	0.000287	-0.00013	8.42E-05	-9E-05	-7.1E-05	3.89E-05	-8.4E-05	0.000111	0.001958
58	0.000867	-0.00065	-2.1E-05	0.00014	-0.00026	0.000403	-0.00038	0.000211	-8.7E-05	3.07E-06	0.000224	-0.0002	0.000159	-8E-05	8.87E-05	-3.5E-05	-7.5E-05	-0.0777
59	0.000424	0.000102	-0.00066	0.000624	-0.00047	7.45E-05	-0.0001	-0.00029	0.000324	-0.00029	6.13E-05	2.47E-06	9.72E-07	0.000125	-0.00011	0.000115	-3.4E-05	-0.15977
60	-0.00048	0.000729	-0.00043	0.000208	5.64E-05	-0.00038	0.000365	-0.00023	6.64E-05	5.1E-05	-0.00024	0.000198	-0.00016	-4.6E-06	-1.9E-06	-7E-05	0.00011	-0.19177
61	-0.00086	0.000477	0.000374	-0.00051	0.000496	-0.00019	0.000169	0.000278	-0.00033	0.000278	1.47E-05	-8.9E-05	8.79E-05	-0.00012	0.000111	-5.2E-05	-7.7E-05	-0.17454
62	-0.0003	-0.00035	0.000682	-0.00049	0.00016	0.000319	-0.00033	0.000247	-4.6E-05	-0.0001	0.000238	-0.00016	0.00011	8.72E-05	-8.6E-05	0.000117	-3.1E-05	-0.15773
63	0.000589	-0.00076	8.82E-05	0.000234	-0.00043	0.000293	-0.00023	-0.00026	0.000331	-0.00026	-8.9E-05	0.000158	-0.00015	6.29E-05	-4.2E-05	-5.5E-05	0.000109	-0.16003
64	0.000835	-0.00025	-0.00062	0.000622	-0.00035	-0.00023	0.00029	-0.00026	2.51E-05	0.000152	-0.00021	9E-05	-2.7E-05	-0.00013	0.00012	-6.7E-05	-8E-05	-0.11378
65	0.000169	0.000556	-0.00051	0.000114	0.000275	-0.00036	0.000286	0.000246	-0.00033	0.00023	0.000155	-0.0002	0.000164	2.5E-05	-5.3E-05	0.000116	-2.8E-05	-0.03973
66	-0.00068	0.000692	0.000277	-0.00056	0.000466	0.000113	-0.00024	0.000279	-4.2E-06	-0.0002	0.000162	-3.9E-06	-6.5E-05	0.000113	-7.8E-05	-3.8E-05	0.000108	-0.07508
67	-0.00079	-6.8E-06	0.000698	-0.00043	-7.2E-05	0.0004	-0.00033	-0.00023	0.000332	-0.00019	-0.00021	0.000199	-0.00013	-0.0001	0.000115	-8.2E-05	-8.2E-05	-0.18681
68	-3.4E-05	-0.0007	0.000196	0.000322	-0.0005	1.16E-05	0.000174	-0.00029	-1.7E-05	0.000231	-9.7E-05	-8.3E-05	0.000136	-4.4E-05	-1.3E-05	0.000112	-2.4E-05	-0.22345
69	0.000757	-0.00055	-0.00057	0.000605	-0.00015	-0.0004	0.000363	0.00021	-0.00033	0.000149	0.000236	-0.00016	5.21E-05	0.000131	-0.0001	-2E-05	0.000107	-0.19312
70	0.000721	0.000263	-0.00058	1.6E-05	0.000434	-0.00014	-0.00011	0.000306	3.75E-05	-0.00026	2.36E-05	0.000154	-0.00017	-4.5E-05	9.6E-05	-9.4E-05	-8.5E-05	-0.14884

71	-0.0001	0.000756	0.000173	-0.0006	0.000335	0.000354	-0.00038	-0.00019	0.000329	-0.0001	-0.00024	9.57E-05	4.02E-05	-0.0001	2.8E-05	0.000105	-2.1E-05	-0.08546
72	-0.00081	0.000338	0.000696	-0.00035	-0.00029	0.000246	3.33E-05	-0.00032	-5.8E-05	0.000279	5.26E-05	-0.0002	0.000143	0.000113	-0.00012	-1.7E-06	0.000106	-0.06654
73	-0.00064	-0.00049	0.000298	0.000402	-0.00046	-0.00028	0.000389	0.000171	-0.00033	4.81E-05	0.000227	-1E-05	-0.00012	2.42E-05	6.59E-05	-0.0001	-8.7E-05	-0.12098
74	0.000236	-0.00073	-0.00049	0.000573	8.74E-05	-0.00033	4E-05	0.000329	7.86E-05	-0.00029	-0.00012	0.0002	-7.6E-05	-0.00013	6.59E-05	9.58E-05	-1.7E-05	-0.17742
75	0.000851	-8.8E-05	-0.00063	-8.2E-05	0.000499	0.000173	-0.00038	-0.00015	0.00032	5.99E-06	-0.00019	-7.7E-05	0.000162	6.37E-05	-0.00012	1.66E-05	0.000105	-0.21641
76	0.000537	0.000655	6.53E-05	-0.00062	0.00013	0.000387	-0.00011	-0.00034	-9.9E-05	0.000286	0.000183	-0.00017	-1.5E-05	8.65E-05	2.8E-05	-0.00011	-8.9E-05	-0.2355
77	-0.00036	0.000608	0.000677	-0.00026	-0.00044	-5.2E-05	0.000361	0.000129	-0.00031	-6E-05	0.000131	0.00015	-0.00015	-0.00012	9.6E-05	8.41E-05	-1.4E-05	-0.20227
78	-0.00087	-0.00017	0.000393	0.000472	-0.00032	-0.0004	0.00018	0.000346	0.000118	-0.00028	-0.00022	0.000101	0.000101	-3.7E-06	-0.0001	3.45E-05	0.000103	-0.13052
79	-0.00042	-0.00074	-0.00041	0.000526	0.000301	-7.4E-05	-0.00033	-0.00011	0.000307	0.000112	-6.1E-05	-0.00019	9.81E-05	0.000125	-1.3E-05	-0.00012	-9.1E-05	-0.00962
80	0.000482	-0.00042	-0.00067	-0.00018	0.000454	0.000379	-0.00024	-0.00035	-0.00014	0.000254	0.000243	-1.7E-05	-0.00016	-8.1E-05	0.000115	7.03E-05	-1E-05	0.180316
81	0.000861	0.000411	-4.4E-05	-0.00063	-0.0001	0.000193	0.000282	8.5E-05	-0.0003	-0.00016	-1.5E-05	0.000201	-1.1E-05	-7E-05	-7.8E-05	5.16E-05	0.000102	0.361445
82	0.0003	0.000747	0.000641	-0.00017	-0.0005	-0.00032	0.000294	0.000358	0.000156	-0.00022	-0.00024	-7.1E-05	0.000162	0.000128	-5.3E-05	-0.00012	-9.3E-05	0.47278
83	-0.00059	0.000182	0.000479	0.00053	-0.00011	-0.00029	-0.00023	-6.2E-05	0.000288	0.000202	8.92E-05	-0.00017	-7.9E-05	-1.7E-05	0.00012	5.47E-05	-6.7E-06	0.500111
84	-0.00083	-0.0006	-0.00032	0.000467	0.000449	0.000227	-0.00034	-0.00036	-0.00017	0.000186	0.00021	0.000145	-0.00012	-0.00012	-4.2E-05	6.74E-05	0.0001	0.420546
85	-0.00017	-0.00066	-0.00069	-0.00027	0.000311	0.000364	0.000163	3.97E-05	-0.00028	-0.00024	-0.00016	0.000107	0.000145	9.6E-05	-8.6E-05	-0.00012	-9.5E-05	0.333404
86	0.000681	7.8E-05	-0.00015	-0.00062	-0.00031	-0.00011	0.000367	0.000365	0.000192	-0.00014	-0.00016	-0.00019	3.71E-05	5.17E-05	0.000111	3.79E-05	-3.2E-06	0.350206
87	0.000788	0.000722	0.00059	-7.5E-05	-0.00045	-0.0004	-4.4E-05	-1.7E-05	0.000265	0.000263	0.000206	-2.3E-05	-0.00017	-0.00013	-1.9E-06	8.16E-05	9.85E-05	0.37884
88	3.39E-05	0.000495	0.000553	0.000575	0.000118	-1.2E-05	-0.00039	-0.00037	-0.00021	9.2E-05	9.75E-05	0.000202	5.52E-05	3.71E-05	-0.00011	-0.00011	-9.7E-05	0.334224
89	-0.00076	-0.00033	-0.00022	0.000396	0.000499	0.000396	2.11E-05	-6.2E-06	-0.00025	-0.00028	-0.00024	-6.5E-05	0.000135	0.000106	8.88E-05	2E-05	3.41E-07	0.247055
90	-0.00072	-0.00076	-0.0007	-0.00015	9.96E-05	0.000135	0.000389	0.000366	0.000225	-3.9E-05	-2.4E-05	-0.00017	-0.00013	-0.00011	3.89E-05	9.37E-05	9.68E-05	0.107879
91	0.000102	-0.00027	-0.00026	-0.00059	-0.00046	-0.00035	5.22E-05	2.92E-05	0.000238	0.000288	0.000244	0.000141	-6.2E-05	-3.2E-05	-0.00012	-0.00011	-9.9E-05	-0.01891
92	0.000814	0.00054	0.000524	2.33E-05	-0.0003	-0.00025	-0.00038	-0.00036	-0.00024	-1.5E-05	-5.3E-05	0.000112	0.000165	0.000131	5.62E-05	1.74E-06	3.88E-06	-0.07743
93	0.000637	0.000701	0.000613	0.000607	0.000325	0.000277	-0.00012	-5.2E-05	-0.00022	-0.00029	-0.00023	-0.00019	-3E-05	-5.6E-05	7.5E-05	0.000104	9.49E-05	0.015925
94	-0.00024	1.7E-05	-0.00011	0.000315	0.00044	0.000333	0.000356	0.00036	0.000253	6.87E-05	0.000124	-2.9E-05	-0.00015	-9.3E-05	-0.00012	-9.6E-05	-0.0001	0.213869
95	-0.00085	-0.00069	-0.00069	-0.00043	-0.00013	-0.00017	0.000191	7.47E-05	0.000207	0.000272	0.000188	0.000202	0.000113	0.000119	1.69E-05	-1.7E-05	7.41E-06	0.424012
96	-0.00054	-0.00056	-0.00036	-0.00056	-0.0005	-0.00039	-0.00032	-0.00036	-0.00027	-0.00012	-0.00018	-5.9E-05	8.51E-05	1.19E-05	0.000102	0.000111	9.3E-05	0.529853

97	0.000363	0.00024	0.000445	0.000121	-8.4E-05	5.15E-05	-0.00025	-9.7E-05	-0.00019	-0.00025	-0.00013	-0.00018	-0.00016	-0.00013	-9.8E-05	-8.4E-05	-0.0001	0.547404
98	0.000867	0.000754	0.000658	0.000623	0.000462	0.000403	0.000273	0.00035	0.000278	0.000167	0.000224	0.000136	4.23E-06	7.42E-05	-2.4E-05	-3.5E-05	1.09E-05	0.27076
99	0.000424	0.000359	5.24E-07	0.000227	0.000286	7.45E-05	0.000302	0.000119	0.000173	0.000218	6.13E-05	0.000117	0.000158	7.68E-05	0.000118	0.000115	9.09E-05	-0.64866
100	-0.00048	-0.00047	-0.00066	-0.0005	-0.00034	-0.00038	-0.00022	-0.00034	-0.00029	-0.00021	-0.00024	-0.00019	-9.2E-05	-0.00013	-6.9E-05	-7E-05	-0.0001	-1.65354